US009239103B2

(12) **United States Patent**
Mellet et al.

(10) **Patent No.: US 9,239,103 B2**
(45) **Date of Patent: Jan. 19, 2016**

(54) **CONTINUOUSLY VARIABLE TRANSMISSION WITH CHAIN OUTPUT**

(71) Applicant: **GM Global Technology Operations LLC**, Detroit, MI (US)

(72) Inventors: **Edward W. Mellet**, Rochester Hills, MI (US); **James M. Hart**, Belleville, MI (US); **Daryl A. Wilton**, Macomb, MI (US); **Clinton E. Carey**, Highland, MI (US)

(73) Assignee: **GM Global Technology Operations, LLC**, Detroit, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/321,084**

(22) Filed: **Jul. 1, 2014**

(65) **Prior Publication Data**

US 2015/0011350 A1 Jan. 8, 2015

Related U.S. Application Data

(60) Provisional application No. 61/842,630, filed on Jul. 3, 2013.

(51) **Int. Cl.**

F16H 37/02	(2006.01)
F16H 3/66	(2006.01)
F16H 3/44	(2006.01)

(52) **U.S. Cl.**

CPC ***F16H 37/022*** (2013.01); ***F16H 3/66*** (2013.01); ***F16H 3/663*** (2013.01); *F16H 2003/442* (2013.01); *F16H 2037/023* (2013.01); *F16H 2200/0034* (2013.01); *F16H 2200/2005* (2013.01); *F16H 2200/2007* (2013.01); *F16H 2200/2023* (2013.01); *F16H 2200/2038* (2013.01)

(58) **Field of Classification Search**

CPC F16H 37/022; F16H 3/66; F16H 3/663; F16H 2037/023; F16H 2200/2023; F16H 2003/442; F16H 2200/2038; F16H 2200/2005; F16H 2200/0034; F16H 2200/2007

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,346,622	A *	8/1982	Pierce	475/56
5,480,361	A	1/1996	Murakami et al.	
5,888,161	A *	3/1999	McCarrick et al.	475/43
5,890,987	A	4/1999	Lamers	
6,106,428	A *	8/2000	Koneda et al.	475/210
6,816,725	B1	11/2004	Lemke et al.	
7,347,800	B2	3/2008	Jackson	
7,397,800	B2	7/2008	Elzur	

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2001-246952 A 9/2001

OTHER PUBLICATIONS

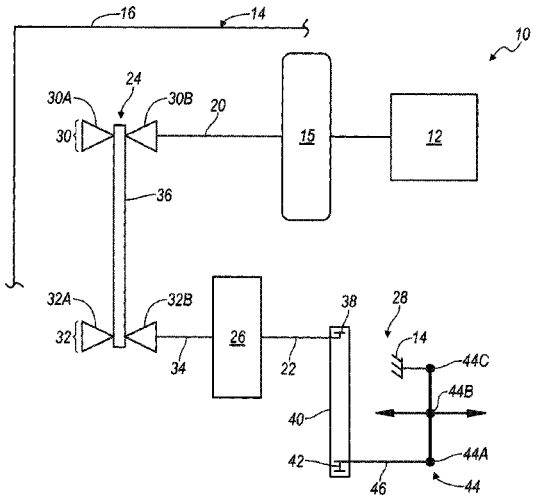
Pending U.S. Appl. No. 61/871,578, filed Aug. 29, 2013, by Edward W. Mellet et al. All Pages.

Primary Examiner — David J Hlavka

(57) **ABSTRACT**

A multi-mode continuously variable transmission in a powertrain of a motor vehicle includes a continuously variable unit connected to a planetary gear set arrangement. The planetary gear set arrangement generally includes two planetary gear sets, two brakes, and one clutch and provides multiple modes of ratio selection between the continuously variable unit and a transmission output member. The transmission output member is connected to a chain driven final having only three axes of rotation.

20 Claims, 22 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,789,795	B2	9/2010	McKenzie et al.	
8,460,137	B2	6/2013	Kajigaya et al.	
8,620,539	B2	12/2013	Urata et al.	
2006/0247086	A1*	11/2006	Watanabe et al.	475/208
2010/0222971	A1*	9/2010	Takahashi et al.	701/51
2010/0227736	A1*	9/2010	Takahashi et al.	477/86
2010/0228449	A1*	9/2010	Takahashi et al.	701/51
2010/0228450	A1*	9/2010	Takahashi et al.	701/51
2011/0015833	A1	1/2011	Urate et al.	
2011/0048552	A1*	3/2011	Dohi et al.	137/511
2012/0244985	A1*	9/2012	Oguri	475/210
2013/0203542	A1*	8/2013	Garcia et al.	475/71

* cited by examiner

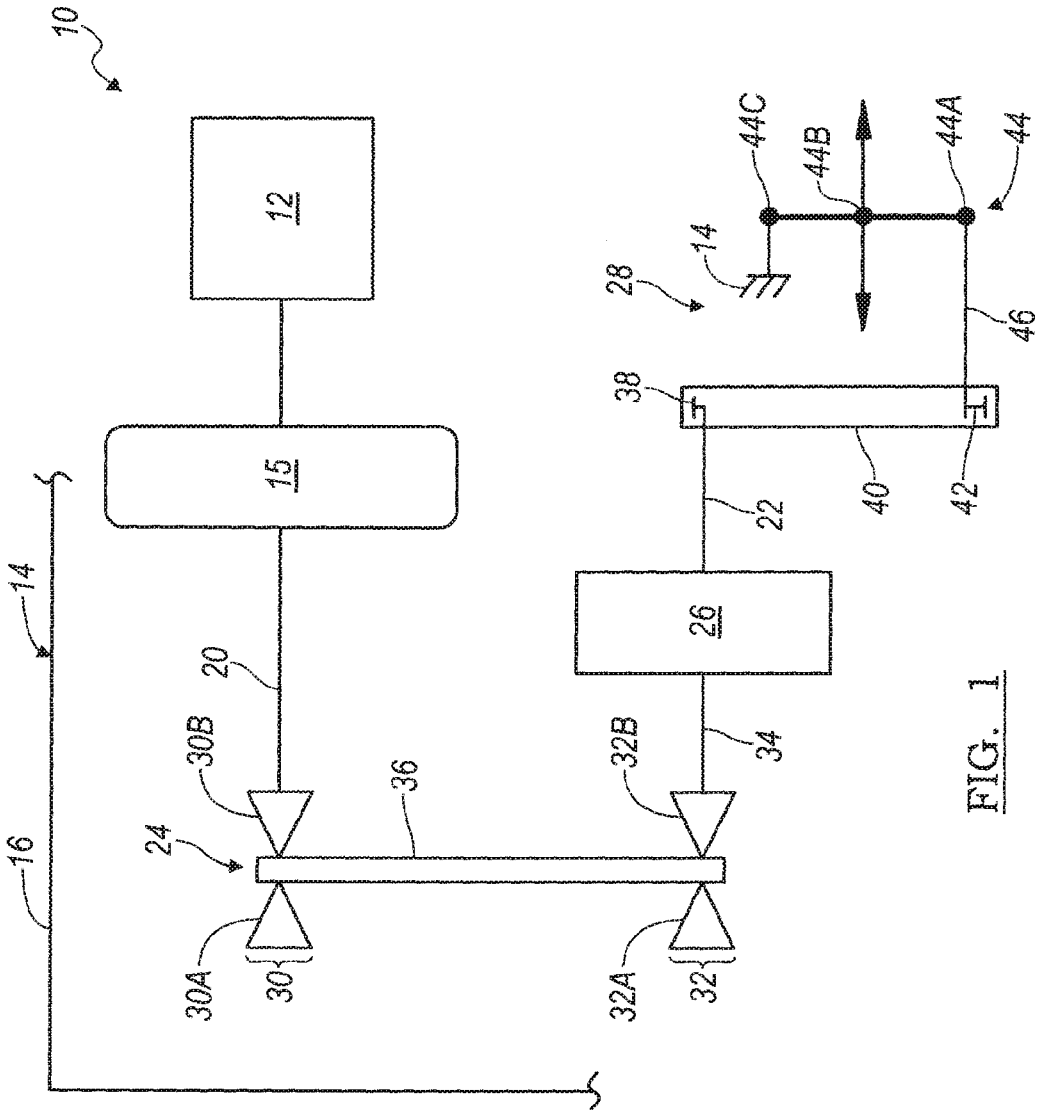

10
12
15
14
16
20
30B
30A
30
24
36
32B
32A
32
34
26
22
38
40
42
28
14
44C
44B
44A
44
46

FIG. 1

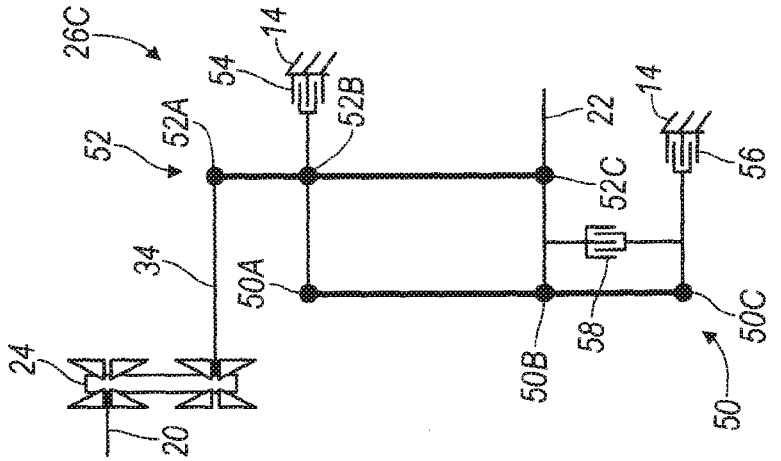


FIG. 2C

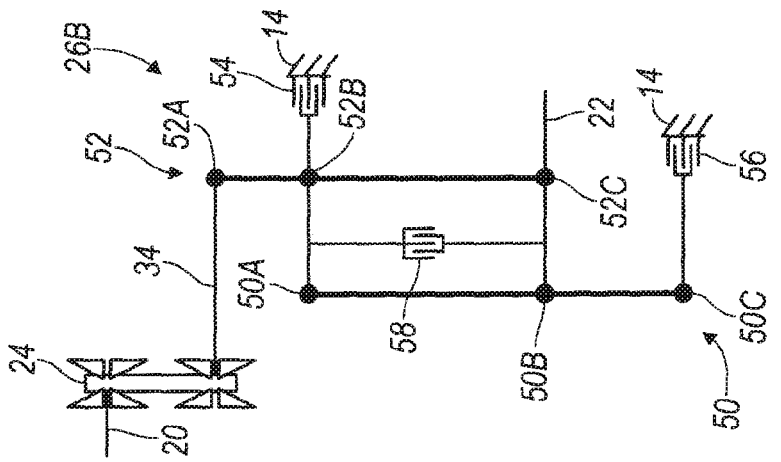


FIG. 2B

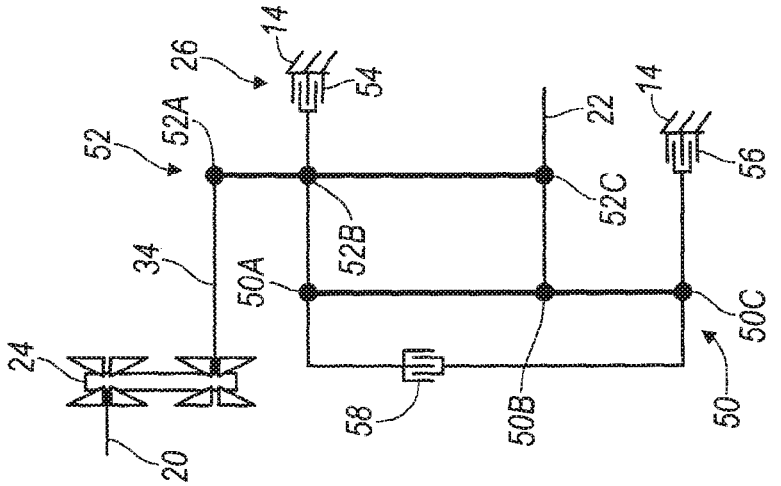


FIG. 2A

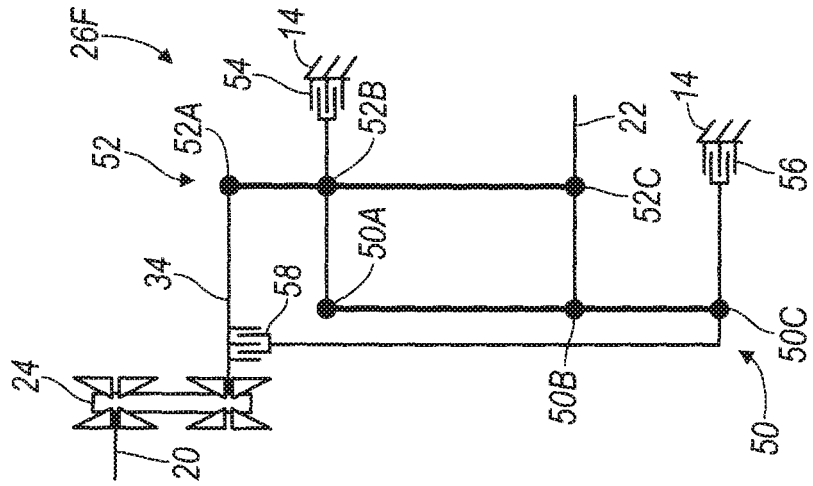


FIG. 2F

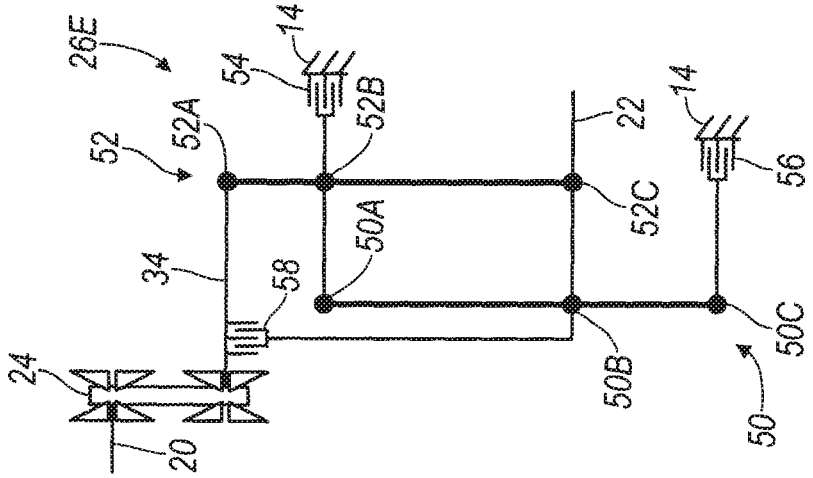


FIG. 2E

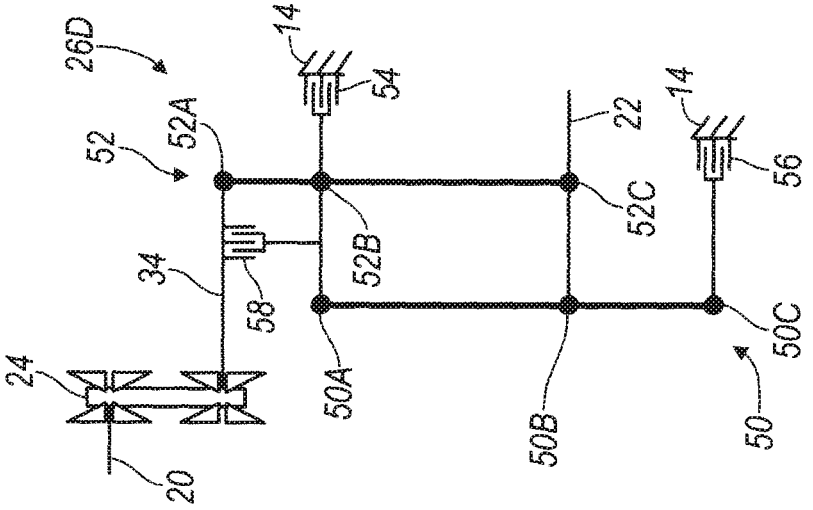


FIG. 2D

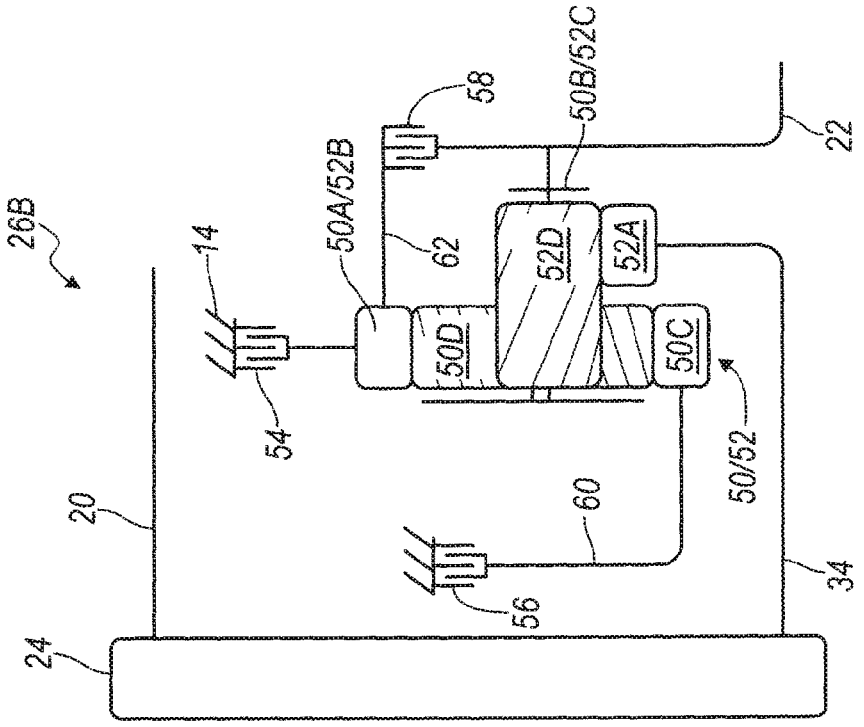

26B
14
50A/52B
62
58
50B/52C
22
52D
52A
50D
50C
54
50/52
20
60
56
34
24

FIG. 3B

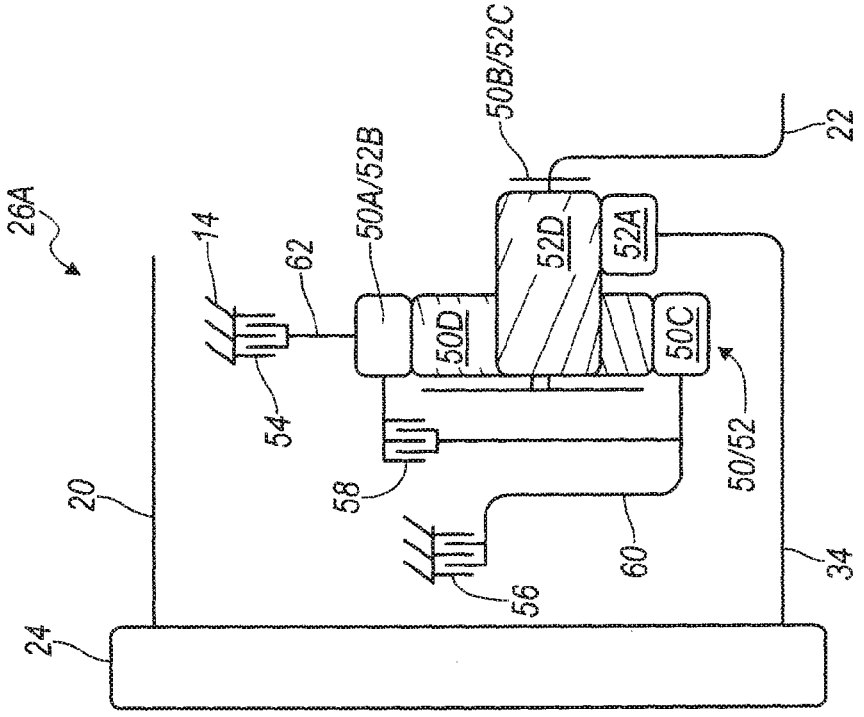

26A
14
62
50A/52B
50B/52C
22
52D
52A
50D
50C
54
50/52
58
20
60
56
34
24

FIG. 3A

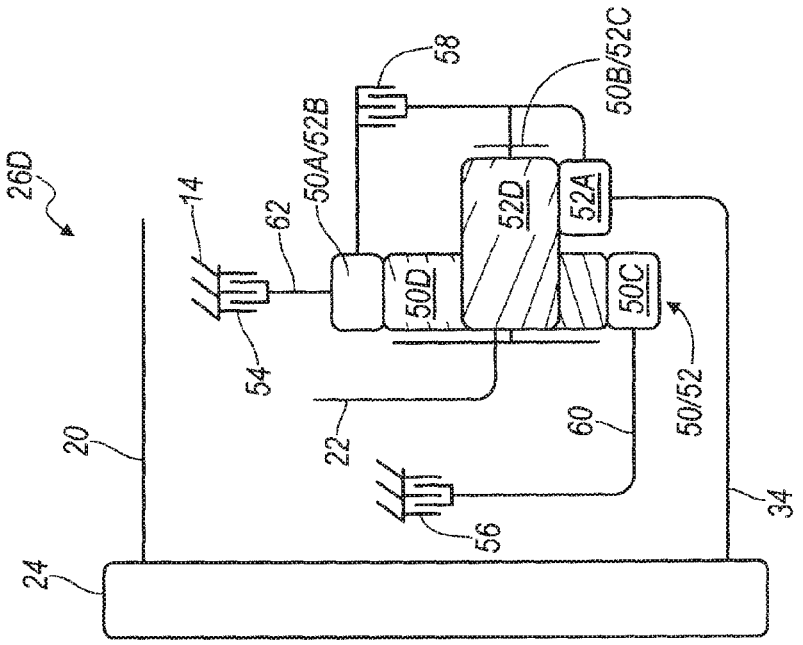

26D
14
62
50A/52B
58
50B/52C
52D
52A
50D
50C
54
22
60
50/52
20
56
34
24

FIG. 3D

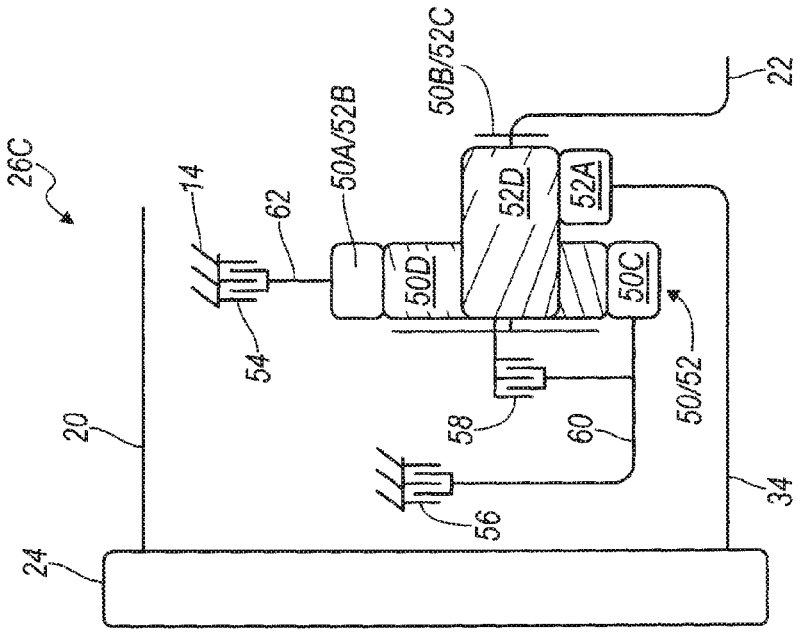

26C
14
62
50A/52B
50B/52C
22
52D
52A
50D
50C
54
58
60
50/52
20
56
34
24

FIG. 3C

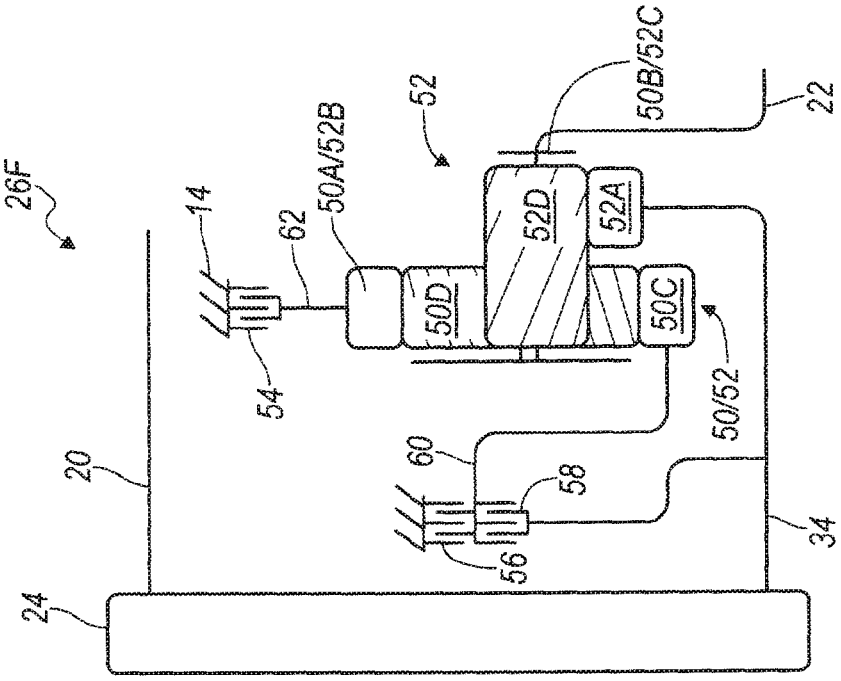

26F
14
62
50A/52B
52
50B/52C
22
52D
52A
50D
50C
54
50/52
60
58
20
34
56
24

FIG. 3F

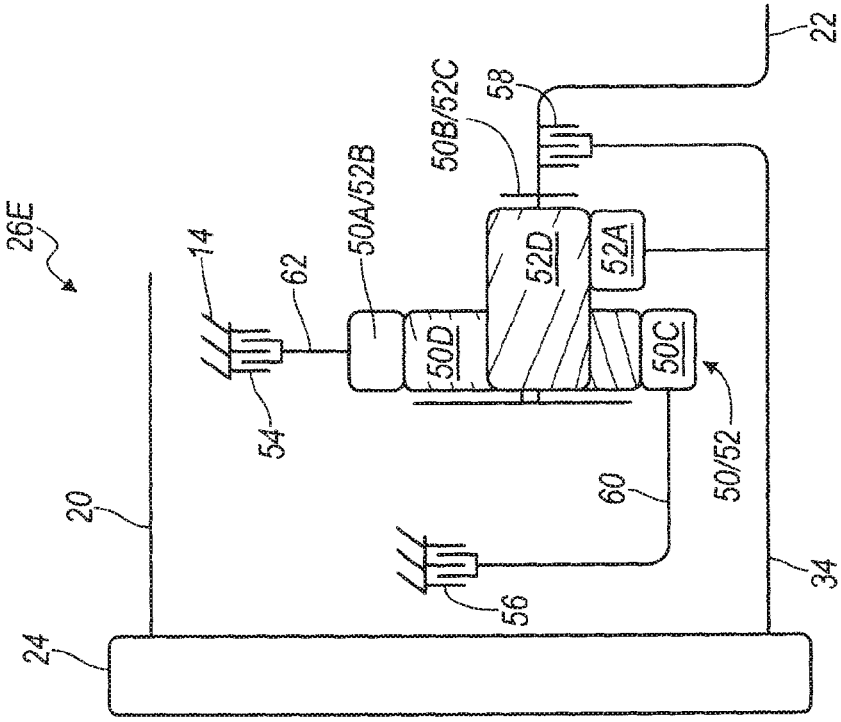

26E
14
62
50A/52B
50B/52C
58
22
52D
52A
50D
50C
54
50/52
60
20
34
56
24

FIG. 3E

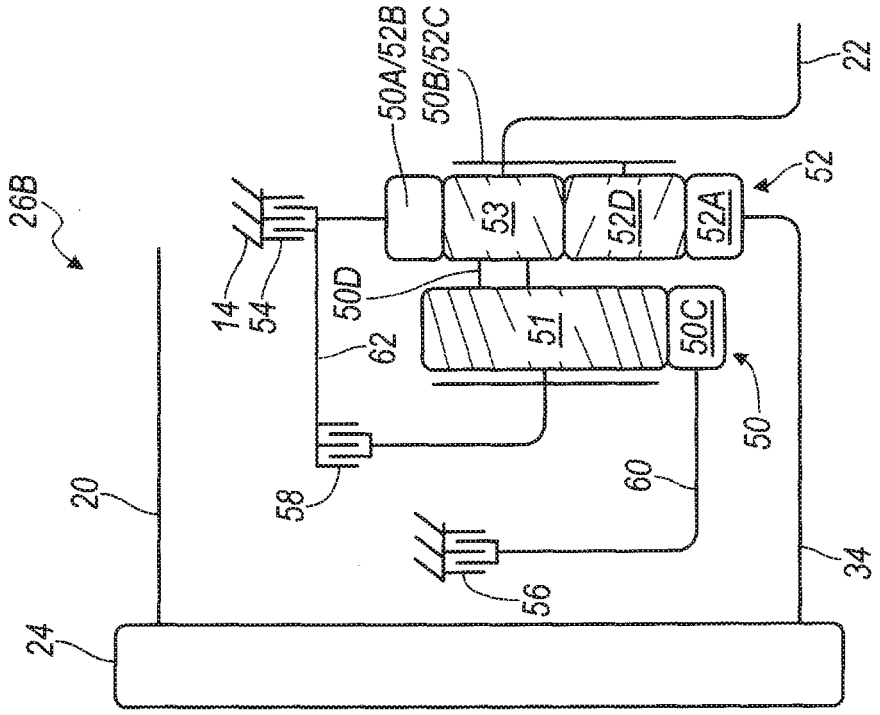

26B
50A/52B
50B/52C
22
52
53
52D
52A
14
54
50D
62
51
50C
50
58
60
20
56
34
24

FIG. 4B

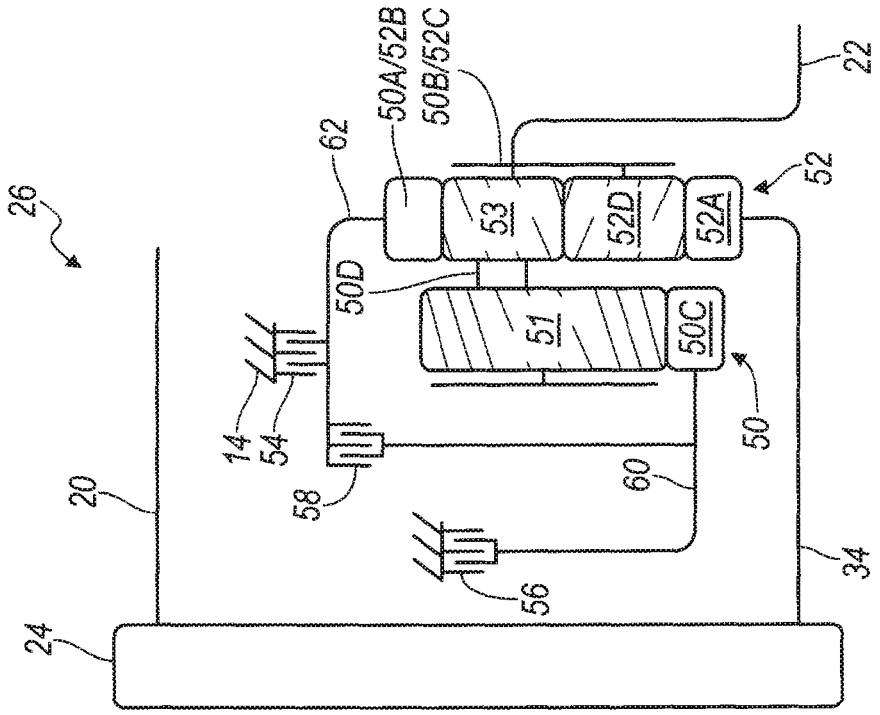

26
62
50A/52B
50B/52C
22
52
53
52D
52A
50D
51
50C
14
54
50
58
60
20
56
34
24

FIG. 4A

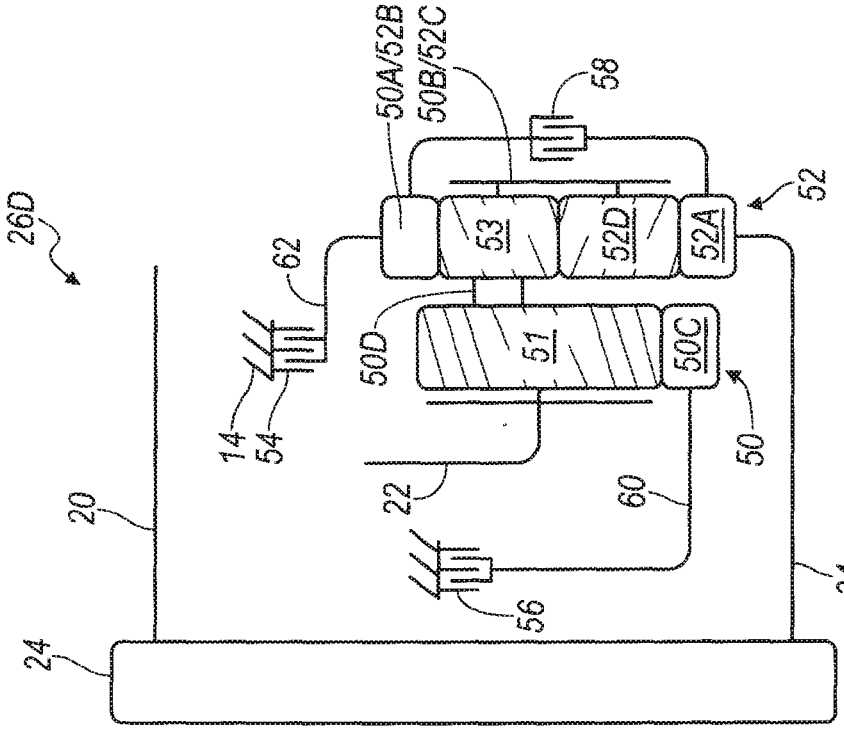

26D
50A/52B
50B/52C
58
52
62
53
52D
52A
50D
51
50C
14
54
50
22
60
20
56
34
24

FIG. 4D

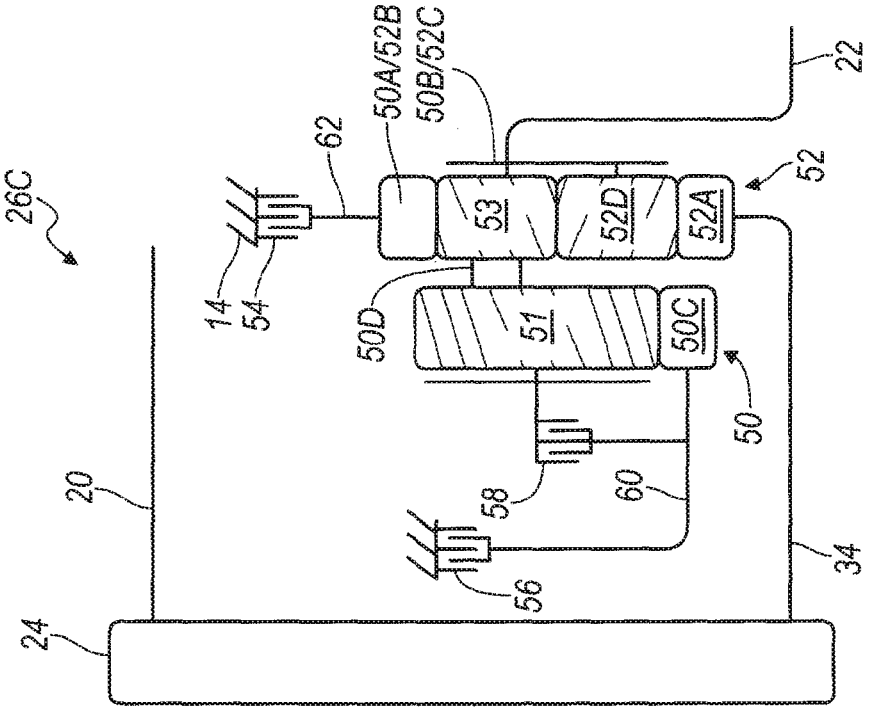

26C
22
50A/52B
50B/52C
62
52
53
52D
52A
14
54
50D
51
50C
50
58
60
20
56
34
24

FIG. 4C

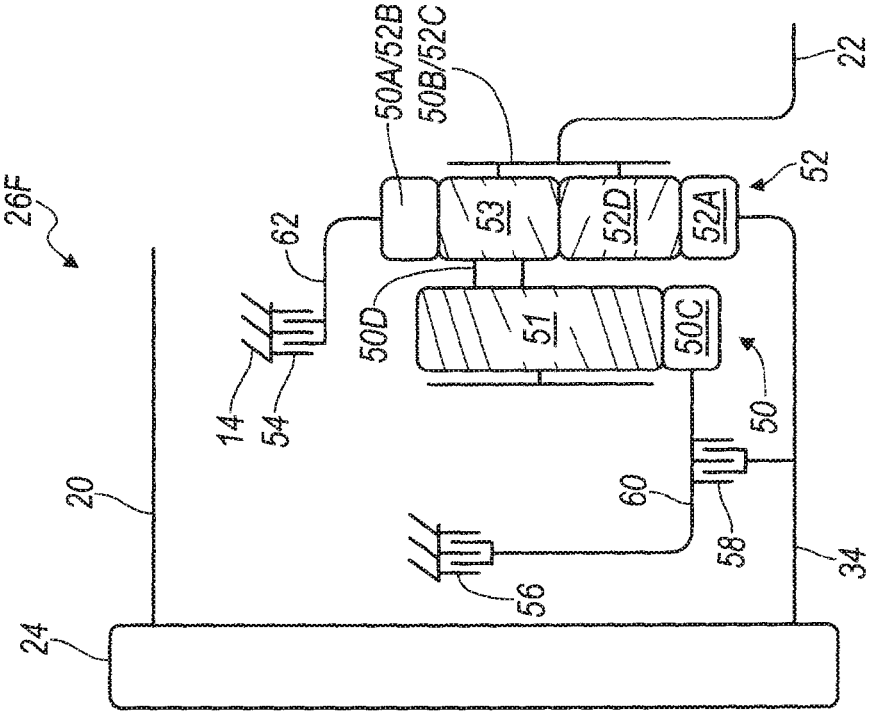

26F
50A/52B
50B/52C
22
52
62
53
52D
52A
50D
51
50C
50
14
54
20
60
58
34
56
24

FIG. 4F

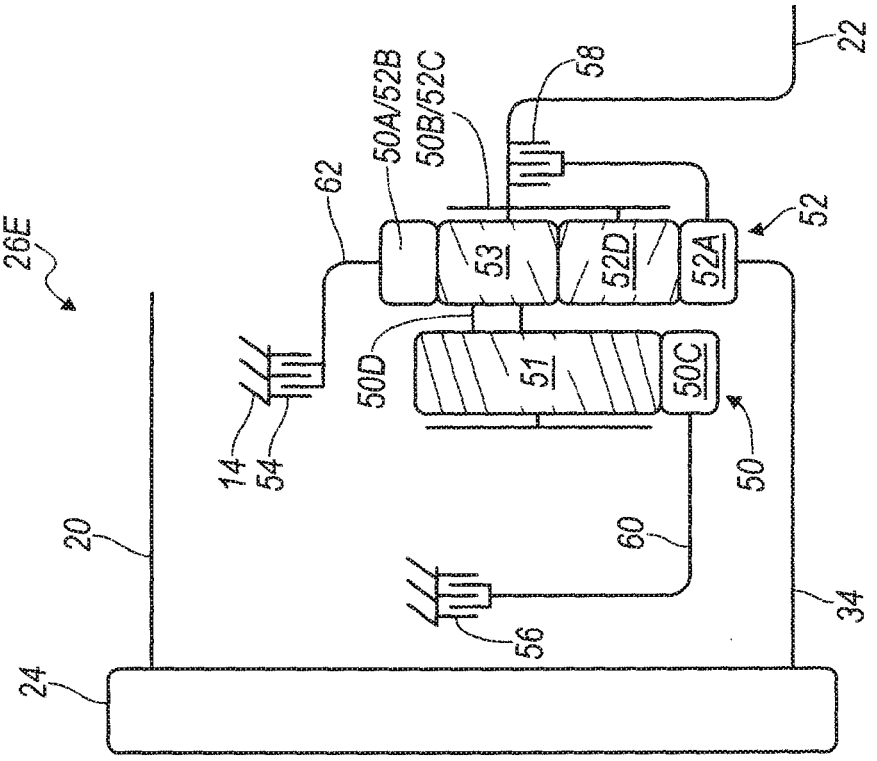

26E
22
58
50A/52B
50B/52C
62
52
53
52D
52A
50D
51
50C
50
14
54
20
60
34
56
24

FIG. 4E

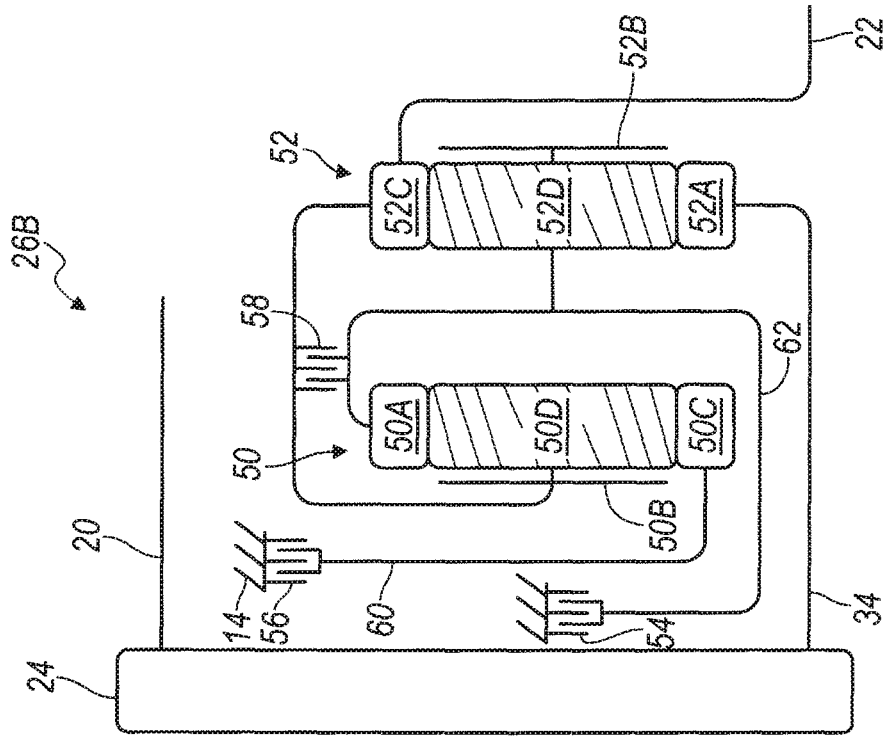

26B
52
52B
22
52C
52D
52A
58
62
50A
50D
50C
50
50B
20
14
56
60
54
34
24

FIG. 5B

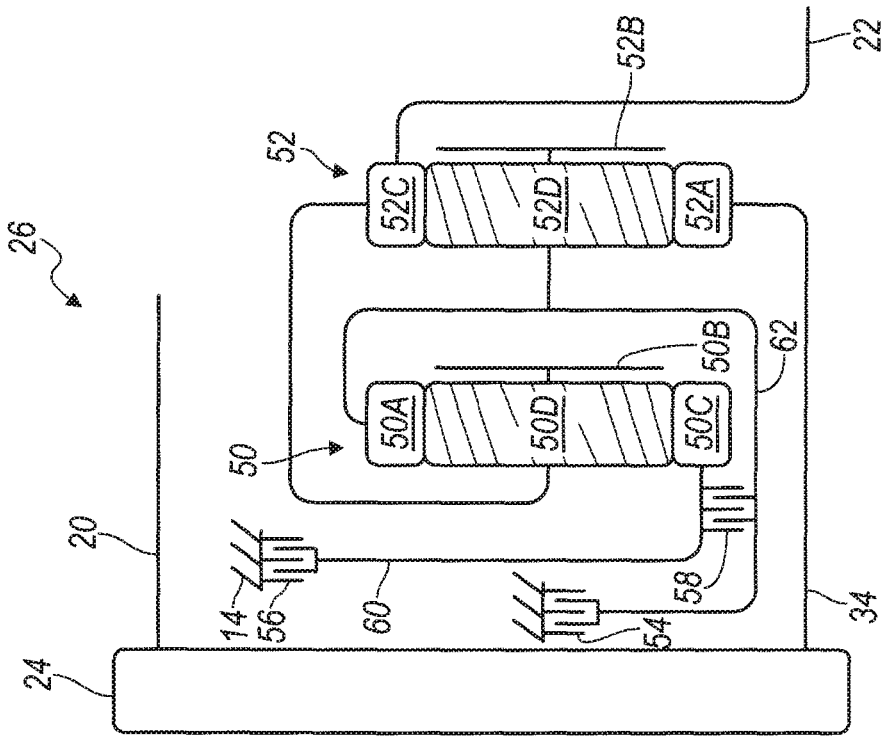

26
52
52B
22
52C
52D
52A
62
50B
50A
50D
50C
50
20
58
14
56
60
54
34
24

FIG. 5A

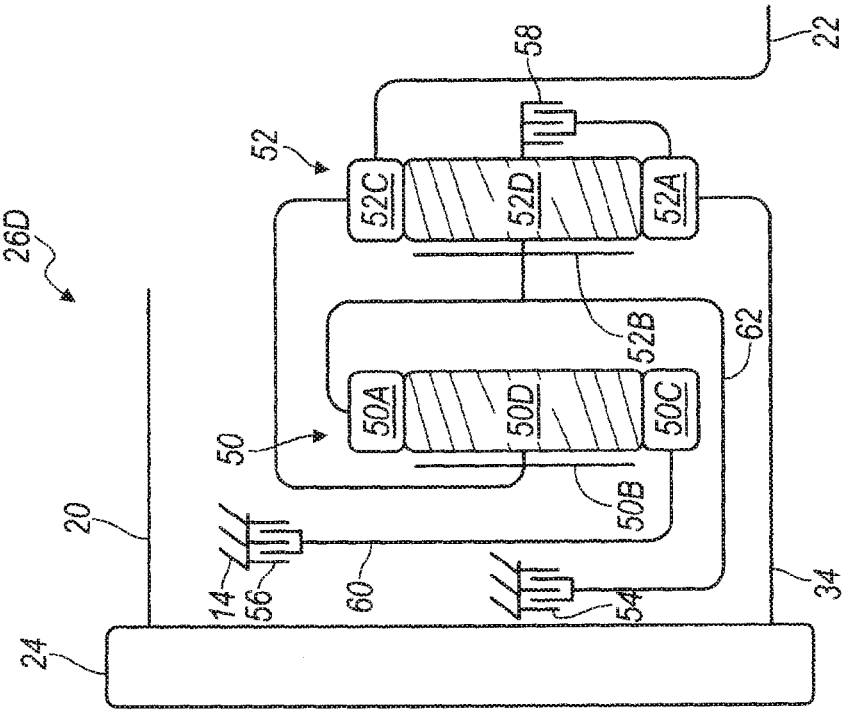

26D
22
58
52
52C
52D
52A
62
52B
50
50A
50D
50C
50B
20
14
56
60
54
34
24

FIG. 5D

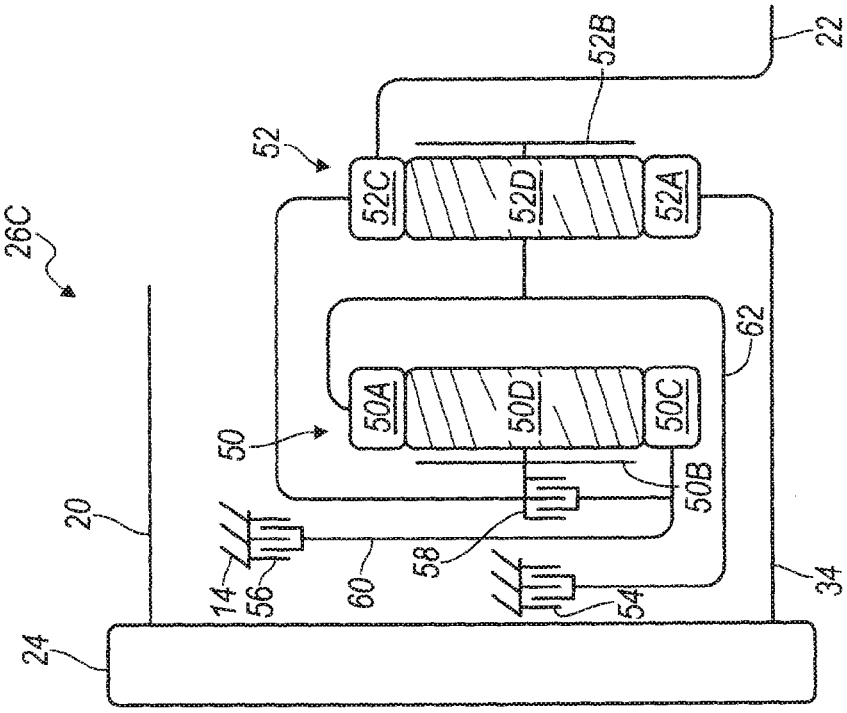

26C
22
52B
52
52C
52D
52A
62
50
50A
50D
50C
50B
20
14
56
60
58
54
34
24

FIG. 5C

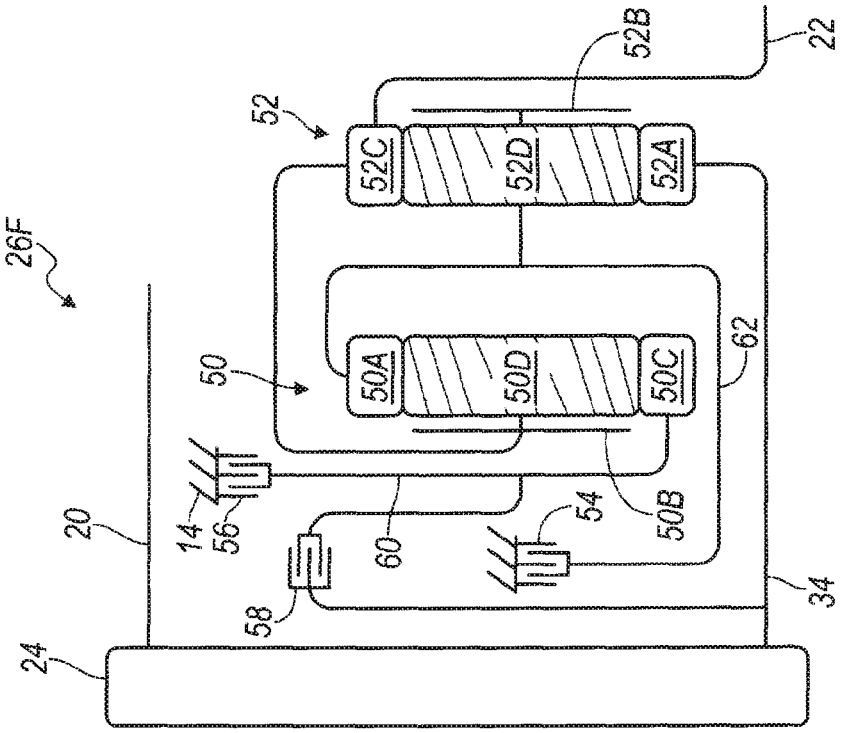

26F
52
52B
22
52C
52D
52A
50
50A
50D
50C
62
20
14
56
60
54
50B
58
34
24

FIG. 5F

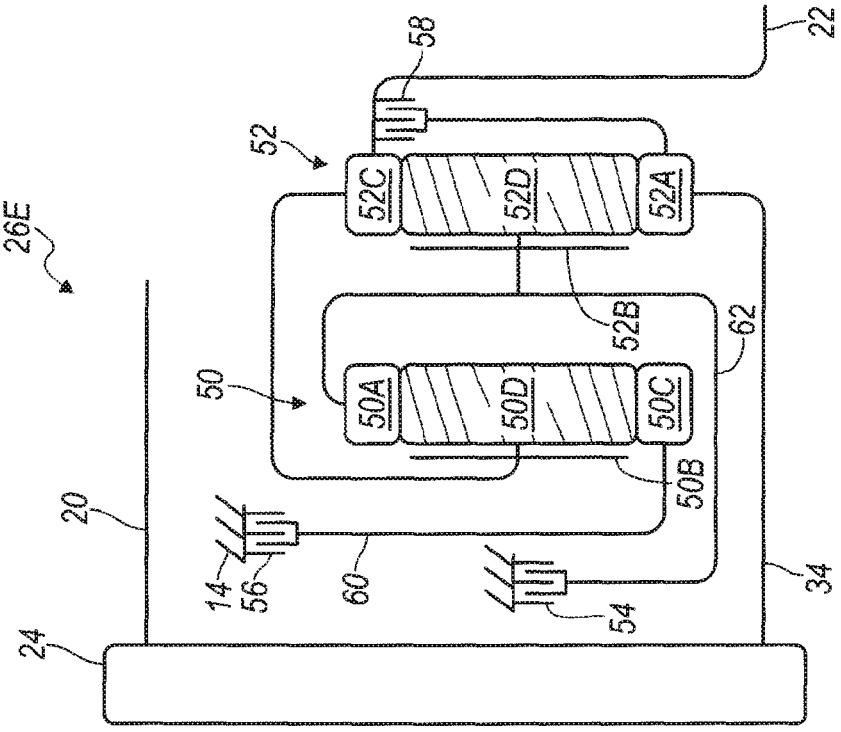

26E
58
22
52
52C
52D
52A
52B
62
50
50A
50D
50C
50B
20
14
56
60
54
34
24

FIG. 5E

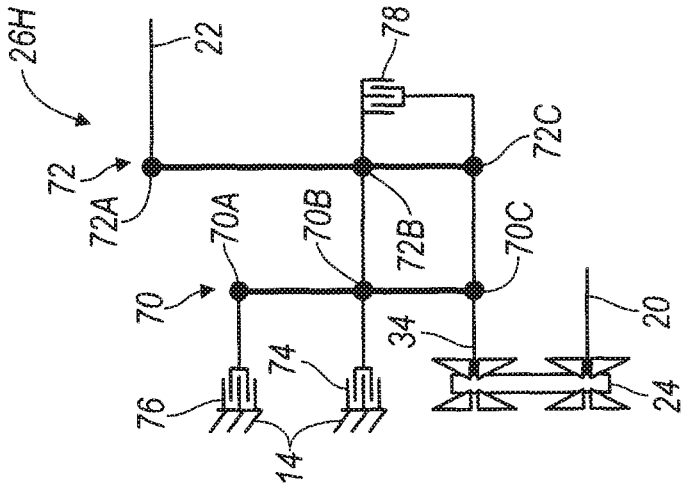


FIG. 6C

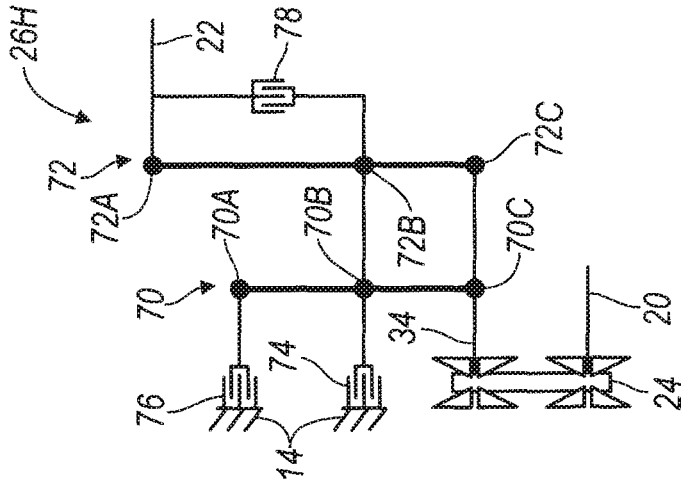


FIG. 6B

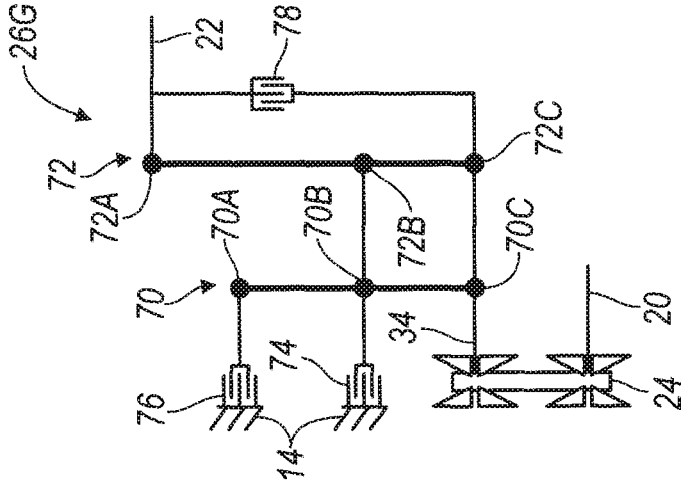


FIG. 6A

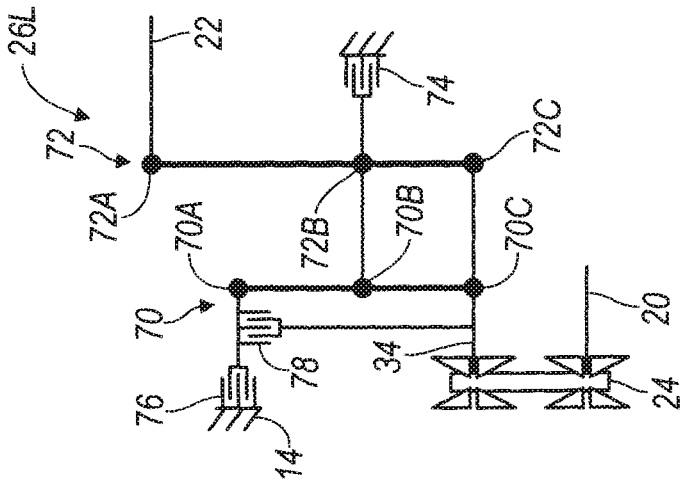


FIG. 6F

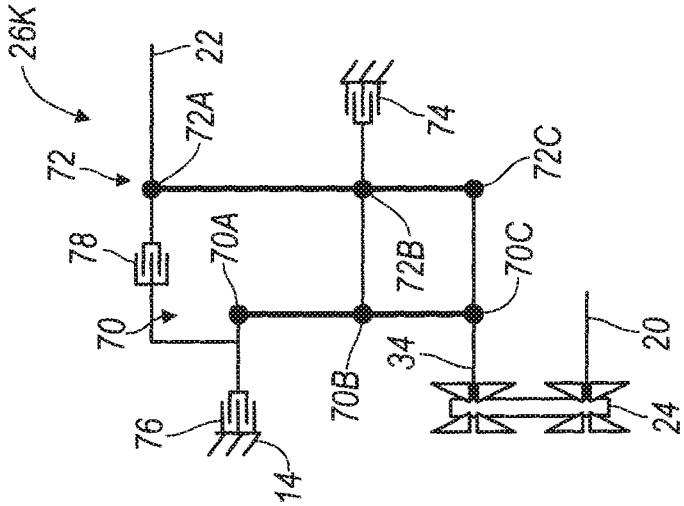


FIG. 6E

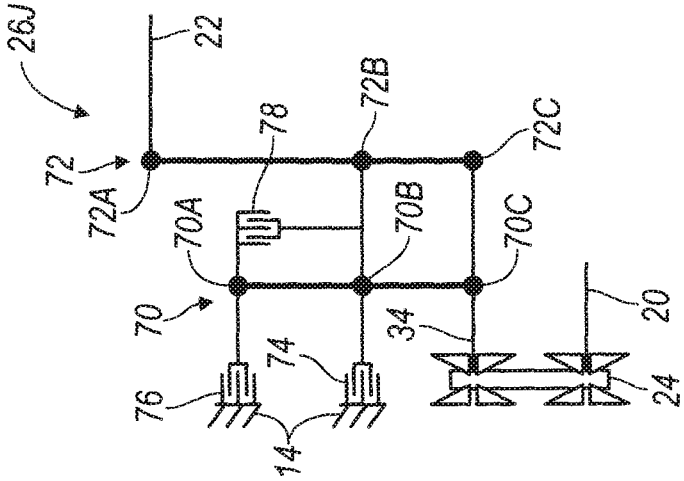


FIG. 6D

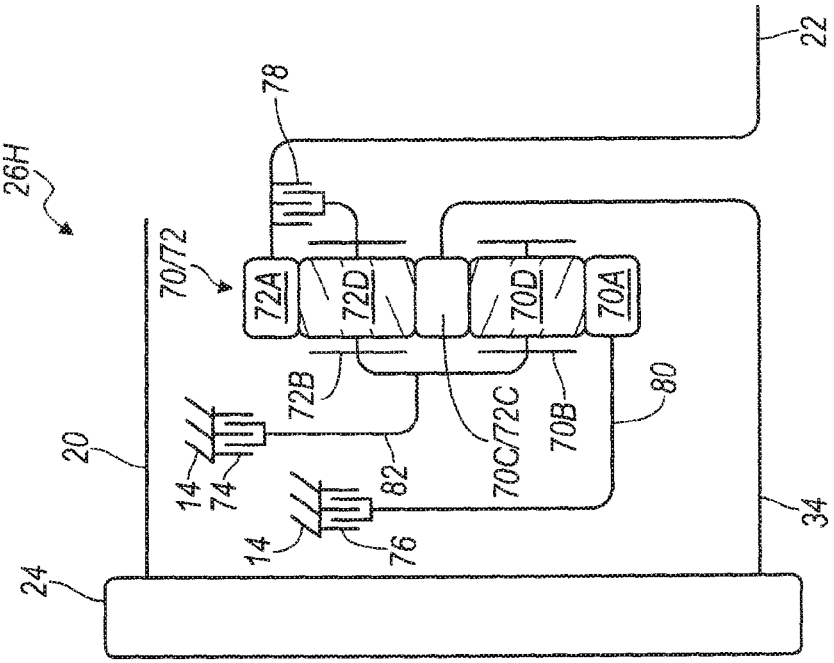

26H
78
22
70/72
72A
72D
70D
70A
72B
80
20
14
74
82
70C/72C
70B
14
76
34
24

FIG. 7B

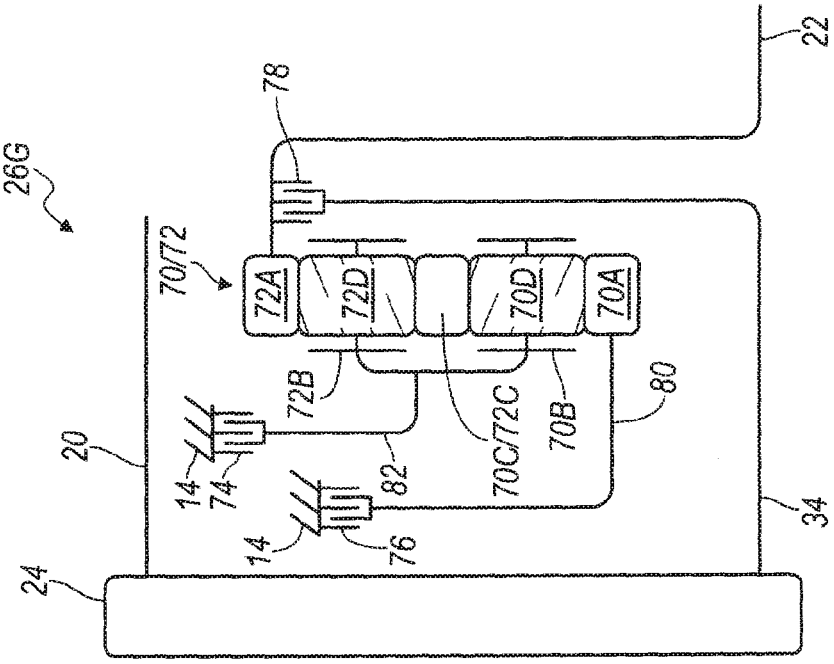

26G
78
22
70/72
72A
72D
70D
70A
72B
80
20
14
74
82
70C/72C
70B
14
76
34
24

FIG. 7A

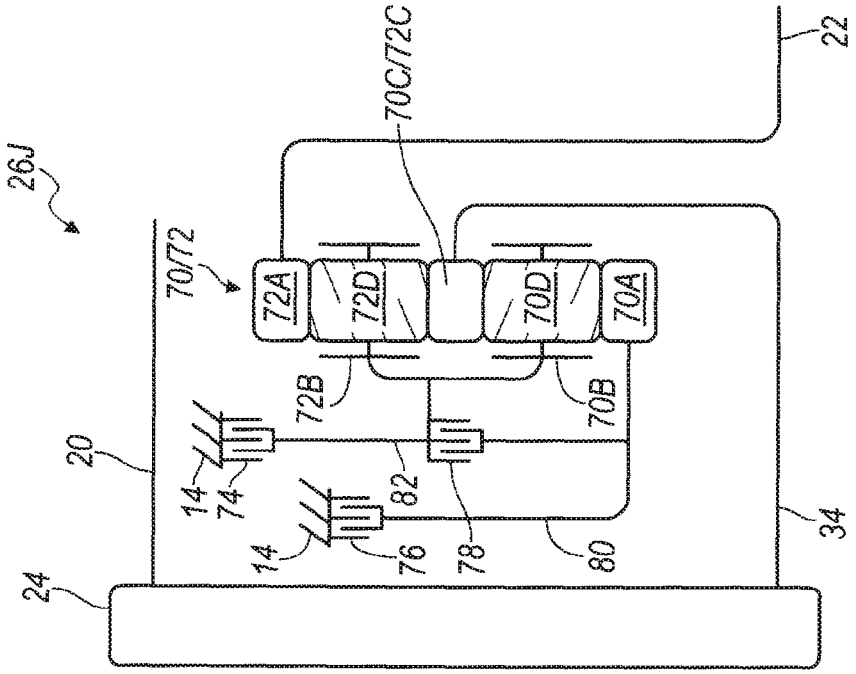

26J
70/72
72A
72D
70C/72C
70D
70A
22
72B
70B
20
14
74
82
78
80
34
14
76
24

FIG. 7D

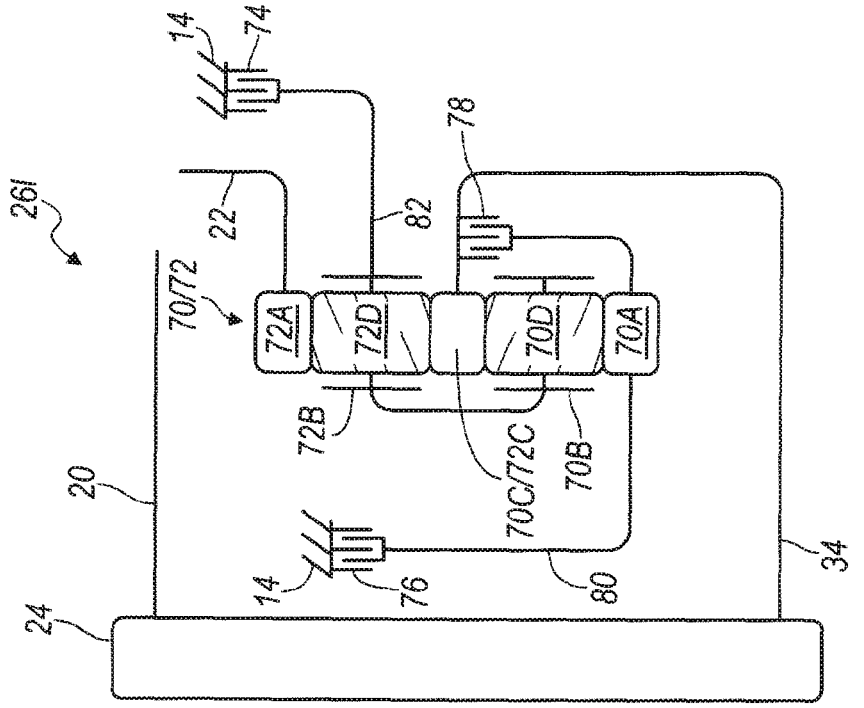

14
74
78
26I
22
82
70/72
72A
72D
70D
70A
72B
70C/72C
70B
20
14
76
80
34
24

FIG. 7C

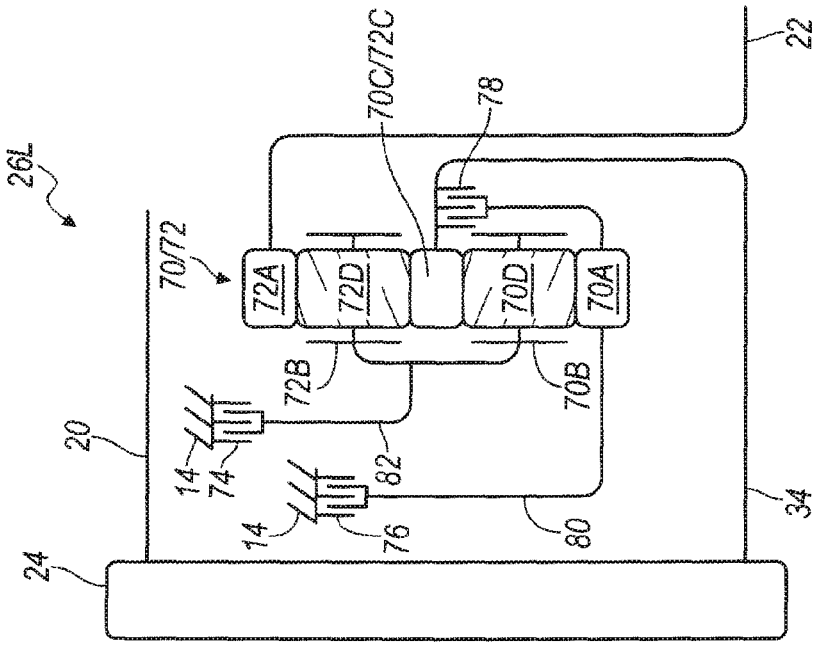

26L
70/72
72A
72D
70D
70A
70C/72C
78
22
72B
70B
20
14
74
82
14
76
80
34
24

FIG. 7F

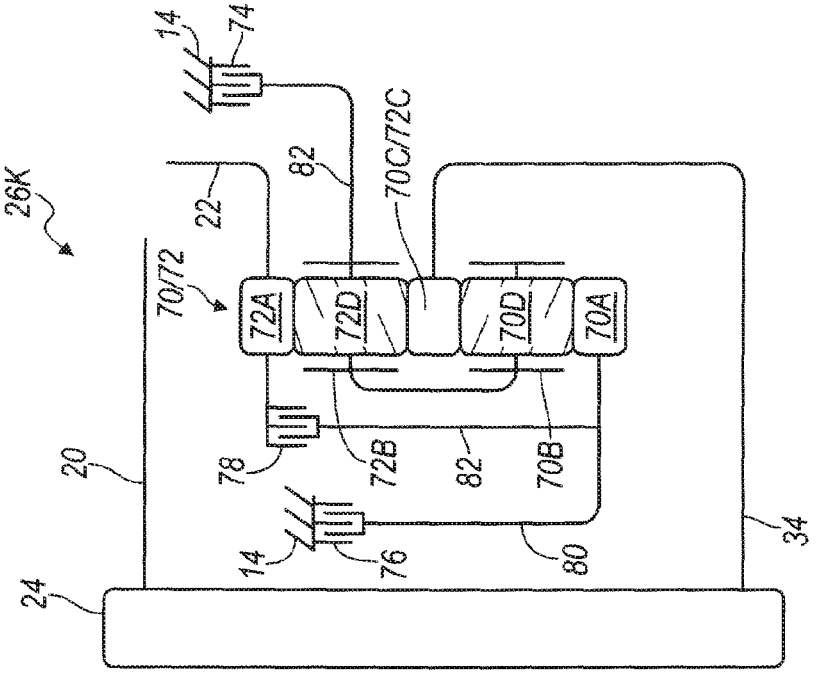

26K
14
74
22
82
70C/72C
70/72
72A
72D
70D
70A
78
72B
82
70B
20
14
76
80
34
24

FIG. 7E

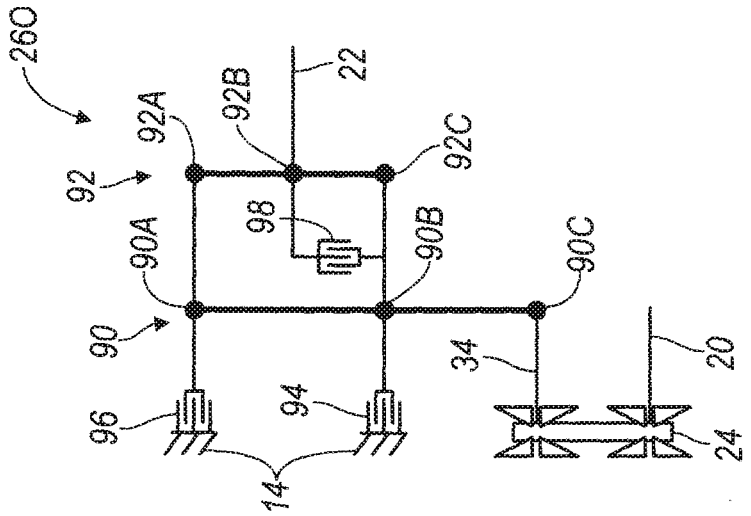


FIG. 8C

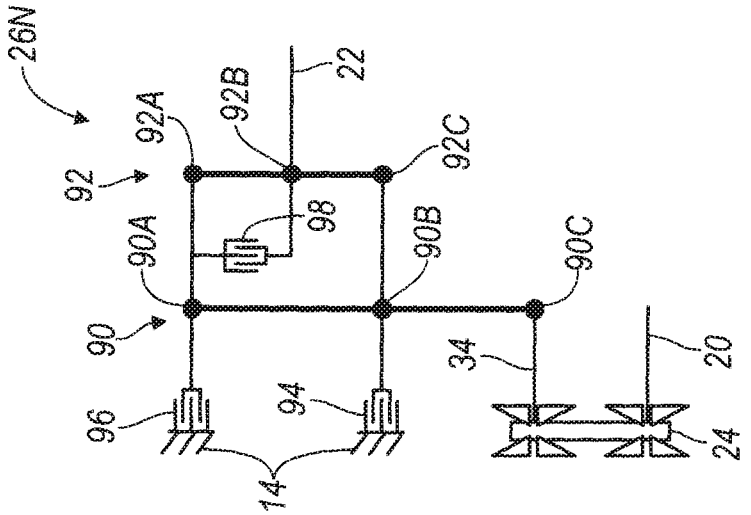


FIG. 8B

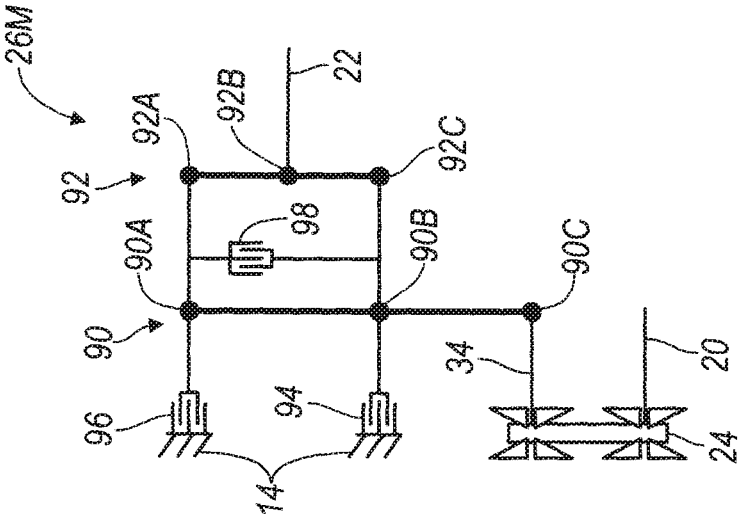


FIG. 8A

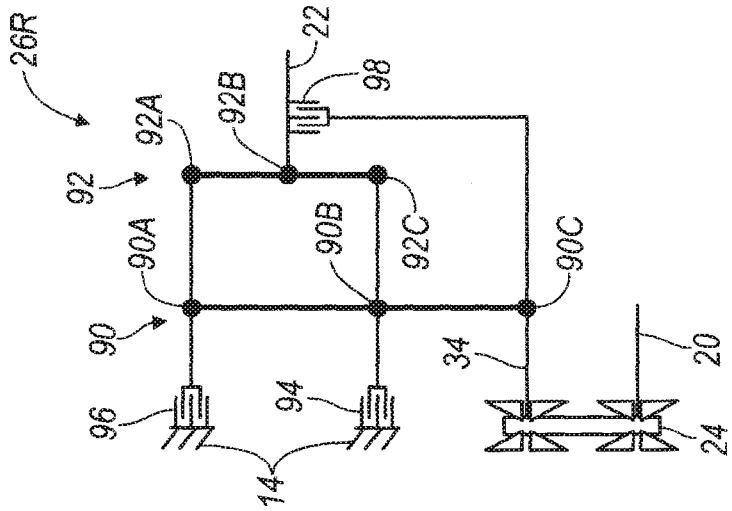


FIG. 8F

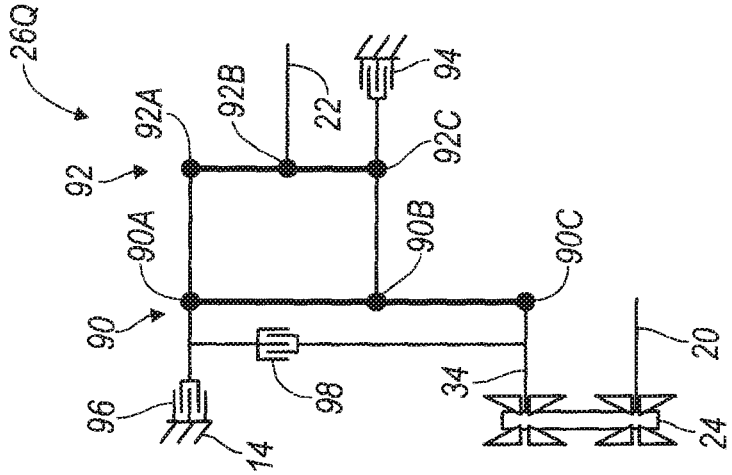


FIG. 8E

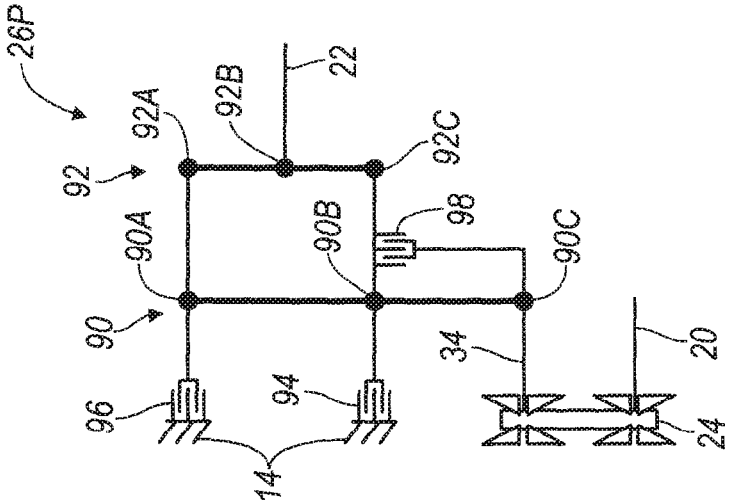


FIG. 8D

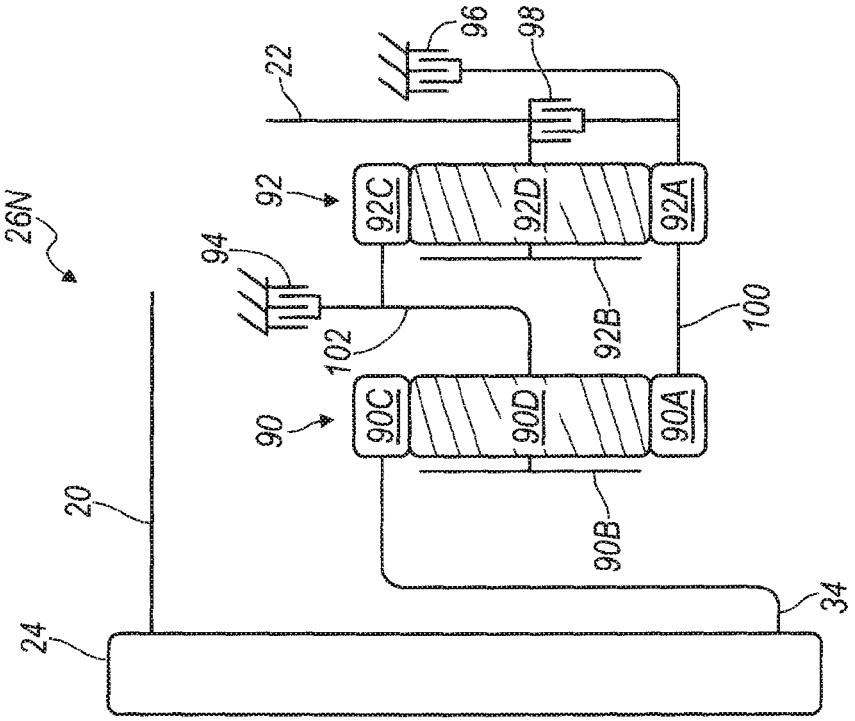

26N
20
24
22
96
98
92
92C
92D
92A
94
102
92B
100
90
90C
90D
90A
90B
34

FIG. 9B

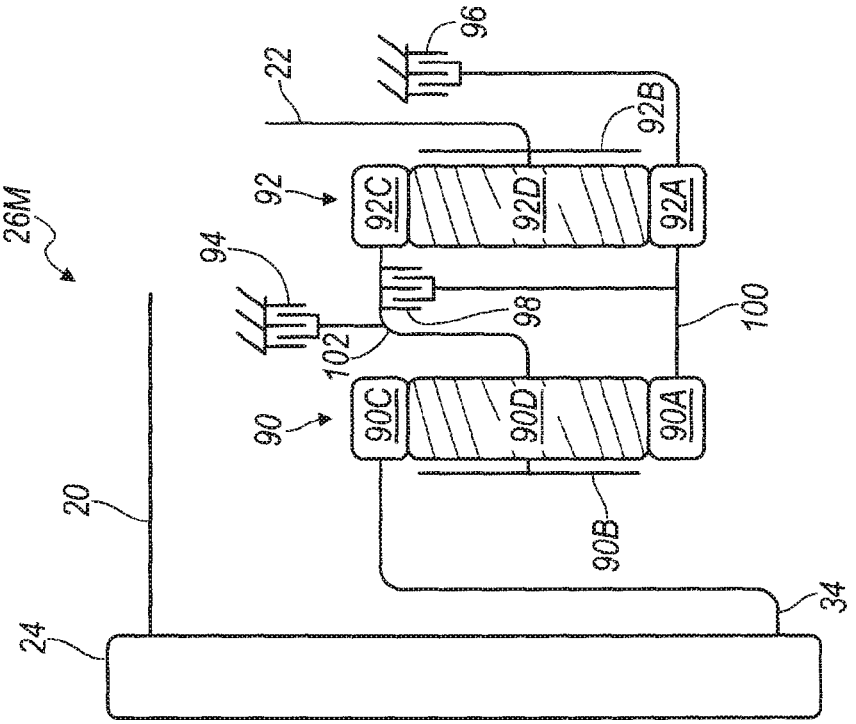

26M
20
24
22
96
92B
92
92C
92D
92A
94
98
102
100
90
90C
90D
90A
90B
34

FIG. 9A

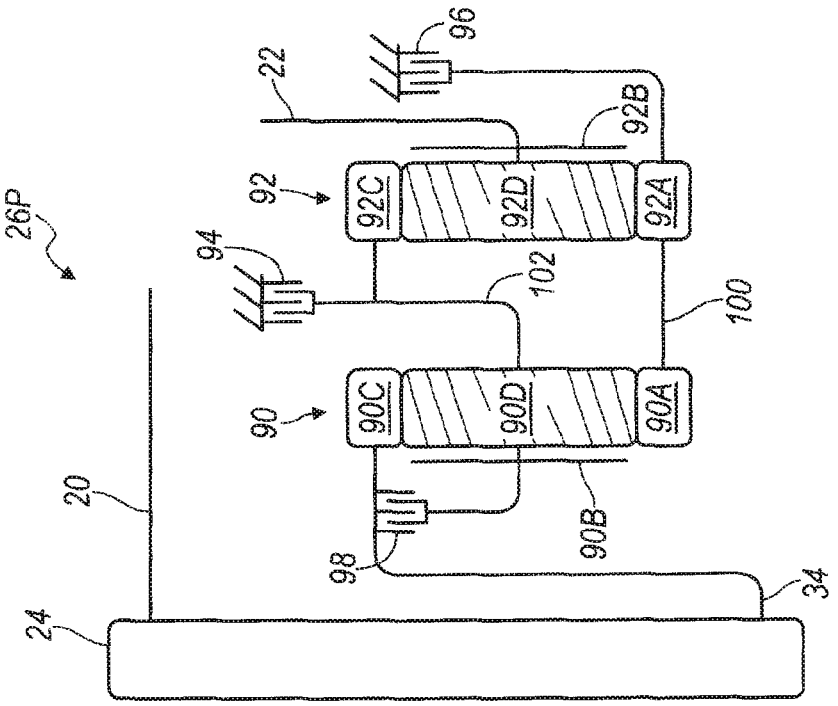

26P
20
24
22
96
92
92C
92D
92A
92B
94
102
100
90
90C
90D
90A
90B
98
34

FIG. 9D

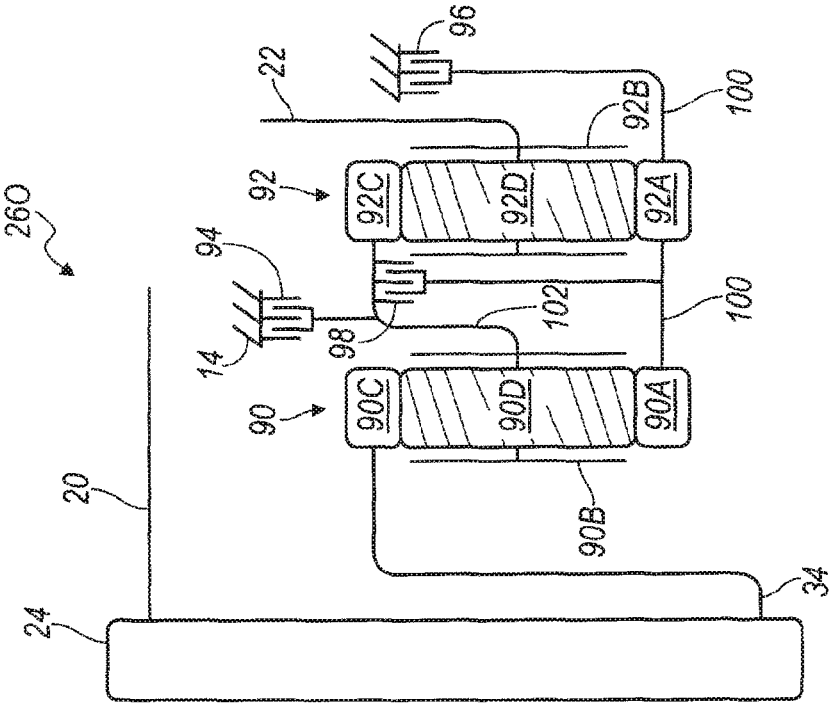

26O
20
24
22
96
92
92C
92D
92A
92B
100
94
14
98
102
90
90C
90D
90A
90B
34

FIG. 9C

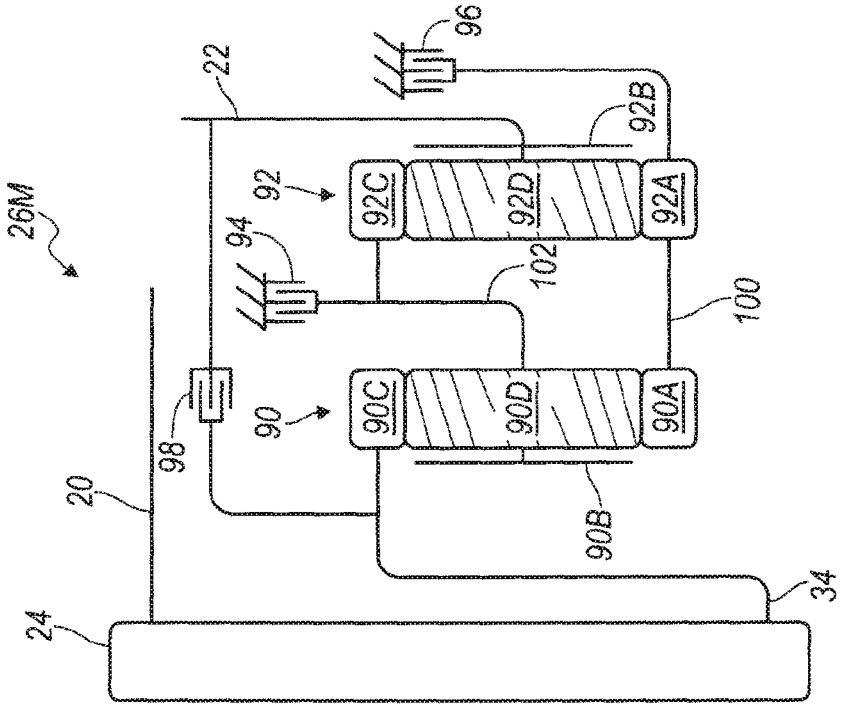

26M
22
96
92B
92
92C
92D
92A
94
102
100
90
90C
90D
90A
98
20
90B
34
24

FIG. 9F

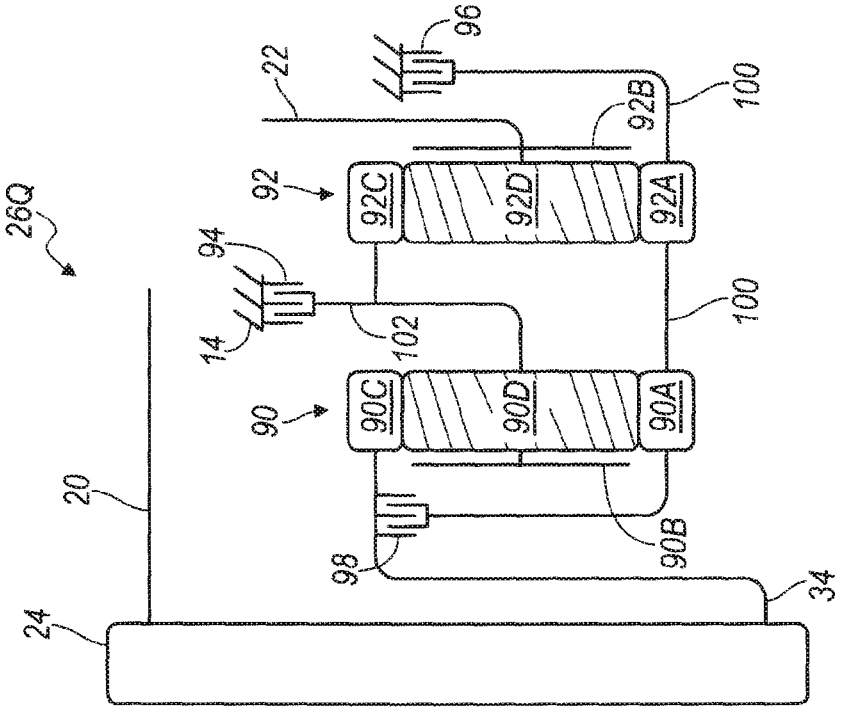

26Q
22
96
92B
100
92
92C
92D
92A
94
14
102
100
90
90C
90D
90A
20
98
90B
34
24

FIG. 9E

CONTINUOUSLY VARIABLE TRANSMISSION WITH CHAIN OUTPUT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/842,630 filed Jul. 3, 2013. The disclosure of the above application is incorporated herein by reference.

FIELD

The present disclosure relates to automatic transmissions and more particularly to a continuously variable transmission having a chain output.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may or may not constitute prior art.

A continuously variable transmission ("CVT") typically includes a belt and pulley system that operatively couples a rotary power source, such as an engine or electric motor, to a double gear final drive unit. The belt and pulley system generally includes first and second pairs of pulley cones having a torque transmitting belt or chain extending between the cone pairs. Each pulley cone pair includes an axially stationary pulley member and an axially movable pulley member. Each movable pulley member is axially adjustable with respect to the stationary pulley member by a hydraulic system. The hydraulic system provides primary and secondary hydraulic pressures to the respective movable pulley members to adjust the running radius of the first and second pulley cone pairs which in turn controls the output/input ratio of the continuously variable transmission. Movement of the cones steplessly or continuously varies the ratio of an input speed to an output speed. With the continuously variable transmission, small but effective ratio changes can be attained. This is in contrast to a fixed gear ratio unit where any ratio changes are step values.

CVT axial length and mass significantly impact its power density and efficiency. Accordingly, there is a constant need for improved CVT designs that minimize axial length and mass while providing sufficient performance characteristics.

SUMMARY

A powertrain for a motor vehicle is provided. The powertrain includes a continuously variable transmission having a continuously variable unit connected to a planetary gear set arrangement. The planetary gear set arrangement generally includes two planetary gear sets, two brakes, and one clutch and provides multiple modes of ratio selection between the continuously variable unit and a transmission output member. The transmission output member is connected to a chain driven final having only three axes of rotation.

In one aspect of the present invention, a powertrain for a motor vehicle includes a transmission input member, a transmission output member, a continuously variable unit having a first pulley pair connected for common rotation with the transmission input member, a second pulley pair, and an endless member wrapped around the first pulley pair and the second pulley pair, a first planetary gear set having a plurality of members, and a second planetary gear set having a plurality of members, wherein the second planetary gear set is connected for common rotation to the first planetary gear set, the continuously variable unit, and the transmission output member. A clutch selectively connects for common rotation the first planetary gear set to the second planetary gear set. A first brake selectively connects the first planetary gear set to a stationary member. A second brake selectively connects the second planetary gear set to the stationary member. A chain drive is connected for common rotation with the transmission output member. A transfer member is connected for common rotation with the chain drive. A final drive planetary gear set is connected for common rotation with the transfer member. The powertrain includes only three axes of rotation from the transmission output member to the final drive planetary gear set.

In another aspect of the present invention, the first planetary gear set includes a first member, a second member, and a third member and the second planetary gear set includes a first member, a second member, and a third member, wherein the first member of the first planetary gear set is connected for common rotation with the second member of the second planetary gear set, and the second member of the first planetary gear set is connected for common rotation with the third member of the second planetary gear set.

In another aspect of the present invention, the first member of the second planetary gear set is connected for common rotation with the second pulley pair and the second member of the first planetary gear set and the third member of the second planetary gear set are connected for common rotation with the transmission output member.

In another aspect of the present invention, the clutch selectively connects for common rotation the first member of the first planetary gear set and the second member of the second planetary gear set to the second member of the first planetary gear set and the third member of the second planetary gear set.

In another aspect of the present invention, the first brake selectively connects the first member of the first planetary gear set and the second member of the second planetary gear set to the stationary member.

In another aspect of the present invention, the second brake selectively connects the third member of the first planetary gear set to the stationary member.

In another aspect of the present invention, the first member of the first planetary gear set and the second member of the second planetary gear set are integrally formed as a single rotating member.

In another aspect of the present invention, the second member of the first planetary gear set and the third member of the second planetary gear set are integrally formed as a single rotating member.

In another aspect of the present invention, the first member of the first planetary gear set is a ring gear, the second member of the first planetary gear set is a planet carrier member, the third member of the first planetary gear set is a sun gear, the first member of the second planetary gear set is a sun gear, the second member of the second planetary gear set is a ring gear, and the third member of the second planetary gear set is a planet carrier member.

In another aspect of the present invention, the second member of the first planetary gear set and the third member of the second planetary gear set both support a plurality of stepped pinions and a plurality of pinions, wherein each of the plurality of stepped pinions have a first portion in mesh with the third member of the first planetary gear set and a second portion in mesh with the integrally formed first member of the first planetary gear set and the second member of the second planetary gear set and in mesh with the plurality of pinions, and wherein the plurality of pinions are in mesh with the first member of the second planetary gear set.

In another aspect of the present invention, the final drive planetary gear set includes a first member, a second member, and a third member, wherein the first member is connected for common rotation with the transfer member, the second member is interconnected to road wheels of the motor vehicle, and the third member is connected to the stationary member.

In another aspect of the present invention, the first member of the final drive planetary gear set is a sun gear, the second member of the final drive planetary gear set is a planet carrier member, and the third member of the final drive planetary gear set is a ring gear.

Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustration purposes only and is not intended to limit the scope of the present disclosure in any way.

FIG. **1** is a schematic diagram of a powertrain according to the principles of the present invention;

FIG. **2**A is a schematic lever diagram of an exemplary transmission according to the principles of the present invention;

FIG. **2**B is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **2**C is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **2**D is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **2**E is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **2**F is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **3**A is a diagrammatic illustration of an embodiment of a transmission according to the principles of the present invention;

FIG. **3**B is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **3**C is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **3**D is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **3**E is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **3**F is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**A is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**B is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**C is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**D is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**E is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **4**F is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**A is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**B is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**C is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**D is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**E is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **5**F is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **6**A is a schematic lever diagram of an exemplary transmission according to the principles of the present invention;

FIG. **6**B is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **6**C is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **6**D is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **6**E is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **6**F is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **7**A is a diagrammatic illustration of an embodiment of a transmission according to the principles of the present invention;

FIG. **7**B is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **7**C is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **7**D is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **7**E is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **7**F is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **8**A is a schematic lever diagram of an exemplary transmission according to the principles of the present invention;

FIG. **8**B is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **8**C is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **8**D is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **8**E is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **8**F is a schematic lever diagram of another exemplary transmission according to the principles of the present invention;

FIG. **9**A is a diagrammatic illustration of an embodiment of a transmission according to the principles of the present invention;

FIG. **9**B is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **9**C is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **9**D is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention;

FIG. **9**E is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention; and

FIG. **9**F is a diagrammatic illustration of another embodiment of a transmission according to the principles of the present invention.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses.

With reference to FIG. **1**, a powertrain for a motor vehicle is generally indicated by reference number **10**. The powertrain **10** generally includes an engine **12** interconnected with a transmission **14**. The engine **12** may be a conventional gasoline, Diesel, or flex fuel internal combustion engine, a hybrid engine, or an electric motor, or any other type of prime mover, without departing from the scope of the present disclosure. The engine **12** supplies a driving torque to the transmission **14** through, for example, a flexplate (not shown) or other connecting device or a starting device **15** such as a hydrodynamic device or launch clutch.

The transmission **14** is a variable diameter pulley or sheave drive continuously variable transmission (CVT). The transmission **14** includes a typically cast, metal housing **16** which encloses and protects the various components of the transmission **14**. The housing **16** includes a variety of apertures, passageways, shoulders and flanges which position and support these components. Generally speaking, the transmission **14** includes a transmission input shaft **20** and a transmission output shaft **22**. Connected between the transmission input shaft **20** and the transmission output shaft **22** is a pulley assembly **24** and a gearbox **26** that cooperate to provide forward and reverse speed or gear ratios between the transmission input shaft **20** and the transmission output shaft **22**. The transmission input shaft **20** is functionally interconnected with the engine **12** through the starting device **15** and receives input torque or power from the engine **12**. The transmission output shaft **22** is preferably connected with a chain driven final drive unit **28**. The transmission output shaft **22** provides drive torque to the final drive unit **28**.

The transmission input shaft **20** is connected to the pulley assembly **24**. The pulley assembly **24** includes a first pulley or sheave pair **30** and a second pulley or sheave pair **32**. The first pulley **30** includes a first truncated conical sheave or member **30**A and second truncated conical sheave or member **30**B in axial alignment with the first truncated conical sheave **30**A. The second sheave **30**B is directly connected for rotation with the transmission input member **20** and may be integrally formed with the transmission input member **20**. The first sheave **30**A is moveable axially relative to the second sheave **30**B by a hydraulic control system (not shown) or other actuating system. It should be appreciated that the sheaves **30**A and **30**B may be axially switched without departing from the scope of the present invention.

The second pulley **32** includes a first truncated conical sheave or member **32**A and second truncated conical sheave or member **32**B in axial alignment with the first truncated conical sheave **32**A. The second sheave **32**B is directly connected for rotation with a transfer shaft or member **34** or may be integrally formed with the transfer shaft **34**. The first sheave **32**A is moveable axially relative to the second sheave **32**B by a hydraulic control system (not shown) or other actuating system. It should be appreciated that the sheaves **32**A and **32**B may be axially switched without departing from the scope of the present invention.

A torque transmitting belt or chain **36** having a V-shaped cross section is mounted between the first pulley pair **30** and the second pulley pair **32**. Drive torque communicated from the transmission input shaft **20** is transferred via friction between the sheaves **30**A and **30**B and the belt **36**. The ratio of the input pulley **30** to the output pulley **32** is adjusted by varying the spacing between the sheaves **30**A and **30**B and between the sheaves **32**A and **32**B. For example, to change the ratio between the pulleys **30** and **32**, the axial distance between sheaves **30**A and **30**B may be reduced by moving sheave **30**A towards sheave **32**B while simultaneously the axial distance between sheave **32**A and **32**B may be increased by moving sheave **32**A away from sheave **32**B. Due to the V-shaped cross section of the belt **36**, the belt **36** rides higher on the first pulley **30** and lower on the second pulley **32**. Therefore the effective diameters of the pulleys **30** and **32** change, which in turn changes the overall gear ratio between the first pulley **30** and the second pulley **32**. Since the radial distance between the pulleys **30** and **32** and the length of the belt **36** is constant, the movement of the sheaves **30**A and **32**A must occur simultaneously in order to maintain the proper amount of tension on the belt **36** to assure torque is transferred from the pulleys **30**, **32** to the belt **36**.

The pulley assembly **24** transfers torque to the gearbox **26** via the transfer shaft **34**. The gearbox **26** comprises one of several planetary gear set transmissions or arrangements, as will be described in greater detail below. The gearbox **26** outputs torque from the pulley assembly **26** to the transmission output shaft **22**.

The transmission output shaft **22** is interconnected with or includes a first spur gear or drive sprocket **38**. A transfer chain **40** is engaged or otherwise meshed with the drive sprocket **38** and engaged or otherwise meshed with a second spur gear or driven sprocket **42**. The driven sprocket **42** is interconnected with a final drive planetary gear set **44** either directly or via a shaft or member **46**.

The final drive planetary gear set **44**, as well as the various gearbox **26** arrangements described below, are illustrated in a lever diagram format. A lever diagram is a schematic representation of the components of a mechanical device such as an automatic transmission. Each individual lever represents a planetary gear set wherein the three basic mechanical components of the planetary gear are each represented by a node. Therefore, a single lever contains three nodes: one for the sun gear, one for the planet gear carrier, and one for the ring gear. In some cases, two levers may be combined into a single lever having more than three nodes (typically four nodes). For example, if two nodes on two different levers are interconnected through a fixed connection they may be represented as a single node on a single lever. The relative length between the nodes of each lever can be used to represent the ring-to-sun ratio of each respective gear set. These lever ratios, in turn, are used to vary the gear ratios of the transmission in order to achieve an appropriate ratios and ratio progression. Mechanical couplings or interconnections between the nodes of the various planetary gear sets are illustrated by thin, horizontal lines and torque transmitting devices such as clutches and brakes are presented as interleaved fingers. Further explanation of the format, purpose and use of lever diagrams can be found in SAE Paper 810102, "The Lever Analogy: A New Tool in Transmission Analysis" by Benford and Leising which is hereby fully incorporated by reference.

For example, the final drive planetary gear set **44** includes a first node **44**A, a second node **44**B, and a third node **44**C. The first node **44**A is coupled to the driven sprocket **42**. The third node **44**C is connected to a fixed or stationary member such as the transmission housing **14**. The second node **44**B is a final drive member that may be interconnected to a differential, drive axles, and vehicle road wheels. In a preferred embodiment, the first node **44**A corresponds to a sun gear, the second node **44**B corresponds to a planet carrier member, and the third node **44**C corresponds to a ring gear. Thus, the powertrain **10** only includes three output axes for drive torque: transmission output shaft **22**, shaft **46**, and the final drive member or planet carrier **44**B. By eliminating the conventional four axis arrangement and having only three axes, the powertrain **10** has greater packaging flexibility since elimination of the fourth axis allows greater flexibility and space to package the shaft **46**.

Turning now to FIGS. **2**A-F, various configurations of the gearbox **26** are shown in lever diagram format. The gearboxes illustrated in FIGS. **2**A-F include specific types of transmissions known as Ravigneaux, powerglide, and RC-RC levers, as will be described below. The gearbox or planetary gear arrangement **26** includes a first planetary gear set **50** and a second planetary gear set **52**. The first planetary gear set **50** has three nodes: a first node **50**A, a second node **50**B and a third node **50**C. The second planetary gear set **52** has three nodes: a first node **52**A, a second node **52**B and a third node **52**C.

The transfer member **34** is continuously coupled to the first node **52**A of the second planetary gear set **52**. The transmission output member **22** is coupled to the third node **52**C of the second planetary gear set **52**. The first node **50**A of the first planetary gear set **50** is coupled to the second node **52**B of the second planetary gear set **52**. The second node **50**B of the first planetary gear set **50** is coupled to the third node **52**C of the second planetary gear set **52**.

A first brake **54** selectively connects the second node **52**B of the second planetary gear set **52** and the first node **50**A of the first planetary gear set **50** with a stationary element or transmission housing **14**. A second brake **56** selectively connects the third node **50**C of the first planetary gear set **50** with the stationary element or transmission housing **14**. A first clutch **58** selectively connects the first node **50**A of the first planetary gear set **50** and the second node **52**B of the second planetary gear set **52** with the third node **50**C of the first planetary gear set **50**.

With reference to FIG. **2**B, an alternate gearbox arrangement **26**B is shown. The gearbox **26**B is similar to that shown in FIG. **2**A and therefore like components are indicated by like reference numbers. However, in FIG. **2**B, the first clutch **58** is relocated and selectively connects the first node **50**A of the first planetary gear set **50** and the second node **52**B of the second planetary gear set **52** with the second node **50**B of the first planetary gear set **50** and the third node **52**C of the second planetary gear set **52**.

With reference to FIG. **2**C, an alternate gearbox arrangement **26**C is shown. The gearbox **26**C is similar to that shown in FIG. **2**A and therefore like components are indicated by like reference numbers. However, in FIG. **2**C, the first clutch **58** is relocated and selectively connects the second node **50**B of the first planetary gear set **50** and the third node **52**C of the second planetary gear set **52** with the third node **50**C of the first planetary gear set **50**.

With reference to FIG. **2**D, an alternate gearbox arrangement **26**D is shown. The gearbox **26**D is similar to that shown in FIG. **2**A and therefore like components are indicated by like reference numbers. However, in FIG. **2**D, the first clutch **58** is relocated and selectively connects the first node **50**A of the first planetary gear set **50** and the second node **52**B of the second planetary gear set **52** with the first node **52**A of the second planetary gear set **52**.

With reference to FIG. **2**E, an alternate gearbox arrangement **26**E is shown. The gearbox **26**E is similar to that shown in FIG. **2**A and therefore like components are indicated by like reference numbers. However, in FIG. **2**E, the first clutch **58** is relocated and selectively connects the second node **50**B of the first planetary gear set **50** and the third node **52**C of the second planetary gear set **52** with the first node **52**A of the second planetary gear set **52**.

With reference to FIG. **2**F, an alternate gearbox arrangement **26**F is shown. The gearbox **26**F is similar to that shown in FIG. **2**A and therefore like components are indicated by like reference numbers. However, in FIG. **2**F, the first clutch **58** is relocated and selectively connects the first node **52**A of the second planetary gear set **52** with the third node **50**C of the first planetary gear set **50**.

Turning now to FIGS. **3**A-F stick diagrams present schematic layouts of embodiments of the gearbox **26**, **26**B-F according to the present invention. In FIGS. **3**A-F the numbering from the lever diagram of FIGS. **2**A-F are carried over. The clutches and couplings are correspondingly presented whereas the nodes of the planetary gear sets now appear as components of planetary gear sets such as sun gears, ring gears, planet gears and planet gear carriers.

For example, the gear sets **50** and **52** include a common planet carrier member **50**B/**52**C, a ring gear member **50**A, a sun gear member **50**C, and a sun gear member **52**A. It should be appreciated that ring gear member **52**B is optional. The common planet carrier member **50**B/**52**C rotatably supports a set of planet gears **50**D (only one of which is shown) and **52**D (only one of which is shown). The planet gears **50**D are each configured to intermesh with the ring gear member **50**A while the planet gears **52**D are long pinions that each intermesh with both the planet gears **50**D and the sun gear member **52**A. The sun gear member **50**C is connected for common rotation with a first shaft or interconnecting member **60**. The sun gear member **52**A is connected for common rotation with the transfer member **34**. The planet carrier member **50**B/**52**C is

connected for common rotation with the transmission output shaft **22**. The ring gear member **50**A is connected for common rotation with a second shaft or interconnecting member **62**.

The torque-transmitting mechanisms or brakes **54**, **56** and clutch **58** allow for selective interconnection of the shafts or interconnecting members, members of the planetary gear sets and the housing. The torque-transmitting mechanisms are friction, dog or synchronizer type mechanisms or the like. For example, the first brake **54** is selectively engageable to connect the second shaft or interconnecting member **62** with the transmission housing **14** in order to restrict relative rotation of the member **62** and therefore the ring gear member **50**A. The second brake **56** is selectively engageable to connect the first shaft or interconnecting member **60** with the transmission housing **14** in order to restrict relative rotation of the member **60** and therefore the sun gear member **50**C. In FIG. **3**A, the clutch **58** is selectively engageable to connect the ring gear member **50**A with the sun gear member **50**C. Likewise, FIGS. **3**B-**3**F illustrate stick diagrams of the corresponding gearbox arrangements **26**B-**26**F which alter the location of the clutch **58**, as described above.

Turning now to FIGS. **4**A-F stick diagrams present schematic layouts of Ravigneaux type embodiments of the gearbox **26**, **26**B-F according to the present invention. In FIGS. **4**A-F the numbering from the lever diagram of FIGS. **2**A-F are carried over. The clutches and couplings are correspondingly presented whereas the nodes of the planetary gear sets now appear as components of planetary gear sets such as sun gears, ring gears, planet gears and planet gear carriers.

For example, the planetary gear set **50** is configured as a simple planetary gear set while planetary gear set **52** is a compound planetary gear set. The gear sets **50** and **52** include a common planet carrier member **50**B/**52**C, a common ring gear member **50**A/**52**B, a first sun gear member **50**C, and a second sun gear member **52**A. The common planet carrier member **50**B/**52**C rotatably supports a set of planet gears or stepped pinions **50**D (only one of which is shown) and planet gear or non-stepped pinions **52**D (only one of which is shown). The planet gears **50**D are each configured to intermesh with both the sun gear member **50**C and the ring gear member **50**A/**52**B. The planet gears **50**D are stepped pinions having a first stepped portion **51** and a second stepped portion **53**. The planet gears **52**D each intermesh with both the stepped portions **53** of the planet gears **50**D and the sun gear member **52**A. The sun gear member **50**C is connected for common rotation with a first shaft or interconnecting member **60**. The sun gear member **52**A is connected for common rotation with the transfer member **34**. The planet carrier member **50**B/**52**C is connected for common rotation with the transmission output shaft **22**. The ring gear member **50**A/**52**B is connected for common rotation with a second shaft or interconnecting member **62**.

The first brake **54** is selectively engageable to connect the second shaft or interconnecting member **62** with the transmission housing **14** in order to restrict relative rotation of the member **62** and therefore the ring gear member **50**A/**52**B. The second brake **56** is selectively engageable to connect the first shaft or interconnecting member **60** with the transmission housing **14** in order to restrict relative rotation of the member **60** and therefore the sun gear member **50**C. In FIG. **4**A, the clutch **58** is selectively engageable to connect the ring gear member **50**A/**52**B with the sun gear member **50**C. Likewise, FIGS. **4**B-**4**F illustrate stick diagrams of the corresponding gearbox arrangements **26**B-**26**F which alter the location of the clutch **58**, as described above.

Turning now to FIGS. **5**A-F stick diagrams present schematic layouts of embodiments of the gearbox **26**, **26**B-F according to the present invention. In FIGS. **5**A-F the numbering from the lever diagram of FIGS. **2**A-F are carried over. The clutches and couplings are correspondingly presented whereas the nodes of the planetary gear sets now appear as components of planetary gear sets such as sun gears, ring gears, planet gears and planet gear carriers.

For example, the planetary gear set **50** includes a sun gear member **50**C, a ring gear member **50**A, and a planet carrier member **50**B that rotatable supports a set of planet gears **50**D (only one of which is shown). The planet gears **50**D are each configured to intermesh with both the sun gear member **50**C and the ring gear member **50**A. The sun gear member **50**C is connected for common rotation with the first shaft or interconnecting member **60**. The ring gear member **50**A is connected for common rotation with the second shaft or interconnecting member **62**. The planet carrier member **50**B is connected for common rotation with the transmission output shaft **22**.

The planetary gear set **52** includes a sun gear member **52**A, a ring gear member **52**C, and a planet carrier member **52**B that rotatable supports a set of planet gears **52**D (only one of which is shown). The planet gears **52**D are each configured to intermesh with both the sun gear member **52**A and the ring gear member **52**C. The sun gear member **52**A is connected for common rotation with the transfer member **34**. The ring gear member **52**C is connected for common rotation with the transmission output member **22**. The planet carrier member **52**B is connected for common rotation with the second interconnecting member **62**.

The first brake **54** is selectively engageable to connect the second shaft or interconnecting member **62** with the transmission housing **14** in order to restrict relative rotation of the member **62** and therefore the ring gear member **50**A and the carrier member **52**B. The second brake **56** is selectively engageable to connect the first shaft or interconnecting member **60** with the transmission housing **14** in order to restrict relative rotation of the member **60** and therefore the sun gear member **50**C. In FIG. **5**A, the clutch **58** is selectively engageable to connect the ring gear member **50**A and the carrier member **52**B with the sun gear member **50**C. Likewise, FIGS. **5**B-**4**F illustrate stick diagrams of the corresponding gearbox arrangements **26**B-**26**F which alter the location of the clutch **58**, as described above.

Turning now to FIGS. **6**A-F, another set of configurations of the gearbox **26** are shown in lever diagram format. The gearboxes illustrated in FIGS. **6**A-F include specific types of transmissions known as stacked planetary gear sets, as will be described below. For example, the gearbox **26**G includes a first planetary gear set **70** and a second planetary gear set **72**. The first planetary gear set **70** has three nodes: a first node **70**A, a second node **70**B and a third node **70**C. The second planetary gear set **72** has three nodes: a first node **72**A, a second node **72**B and a third node **72**C.

The transfer member **34** is continuously coupled to the third node **70**C of the first planetary gear set **70** or to the third node **72**C of the second planetary gear set **72**. The transmission output member **22** is coupled to the first node **72**A of the second planetary gear set **72**. The second node **70**B of the first planetary gear set **70** is coupled to the second node **72**B of the second planetary gear set **72**. The third node **70**C of the first planetary gear set **70** is coupled to the third node **72**C of the second planetary gear set **72**.

A first brake **74** selectively connects the second node **70**B of the first planetary gear set **70** and the second node **72**B of the second planetary gear set **72** with a stationary member or transmission housing **14**. A second brake **76** selectively connects the first node **70**A of the first planetary gear set **70** with

the stationary member or transmission housing **14**. A first clutch **78** selectively connects the third node **70**C of the first planetary gear set **70** and the third node **72**C of the second planetary gear set **72** with the first node **72**A of the second planetary gear set **72** and the transmission output member **22**.

With reference to FIG. **6**B, an alternate gearbox arrangement **26**H is shown. The gearbox **26**H is similar to that shown in FIG. **6**A and therefore like components are indicated by like reference numbers. However, in FIG. **6**B, the first clutch **78** is relocated and selectively connects the second node **70**B of the first planetary gear set **70** and the second node **72**B of the second planetary gear set **72** with the first node **72**A of the second planetary gear set **72** and the transmission output member **22**

With reference to FIG. **6**C, an alternate gearbox arrangement **26**I is shown. The gearbox **26**I is similar to that shown in FIG. **6**A and therefore like components are indicated by like reference numbers. However, in FIG. **6**C, the first clutch **78** is relocated and selectively the second node **70**B of the first planetary gear set **70** and the second node **72**B of the second planetary gear set **72** with the third node **70**C of the first planetary gear set **70** and the third node **72**C of the second planetary gear set **72**.

With reference to FIG. **6**D, an alternate gearbox arrangement **26**J is shown. The gearbox **26**J is similar to that shown in FIG. **6**A and therefore like components are indicated by like reference numbers. However, in FIG. **6**D, the first clutch **78** is relocated and selectively connects the second node **70**B of the first planetary gear set **70** and the second node **72**B of the second planetary gear set **72** with the first node **70**A of the first planetary gear set **70**.

With reference to FIG. **6**E, an alternate gearbox arrangement **26**K is shown. The gearbox **26**K is similar to that shown in FIG. **6**A and therefore like components are indicated by like reference numbers. However, in FIG. **6**E, the first clutch **78** is relocated and selectively connects first node **70**A of the first planetary gear set **70** with the first node **72**A of the second planetary gear set **72**.

With reference to FIG. **6**F, an alternate gearbox arrangement **26**L is shown. The gearbox **26**L is similar to that shown in FIG. **6**A and therefore like components are indicated by like reference numbers. However, in FIG. **6**F, the first clutch **78** is relocated and selectively connects the first node **70**A of the first planetary gear set **70** with the third node **70**C of the first planetary gear set and the third node **72**C of the second planetary gear set **72**.

Turning now to FIGS. **7**A-F, stick diagrams present schematic layouts of embodiments of the gearbox **26**G-L according to the present invention. In FIGS. **7**A-F the numbering from the lever diagram of FIGS. **6**A-F are carried over. The clutches and couplings are correspondingly presented whereas the nodes of the planetary gear sets now appear as components of planetary gear sets such as sun gears, ring gears, planet gears and planet gear carriers.

For example, the planetary gear set **70** and the planetary gear set **72** are configured as a stacked planetary gear set wherein the first planetary gear set **70** is nested radially inward of the second planetary gear set **72**. The planetary gear set **70** includes a sun gear member **70**A, a ring gear member **70**C, and a planet carrier member **70**B that rotatably supports a set of planet gears **70**D (only one of which is shown). The planet gears **70**D are each configured to intermesh with both the sun gear member **70**A and the ring gear member **70**C. The sun gear member **70**A is connected for common rotation with a first shaft or interconnecting member **80**. The ring gear member **70**C is connected for common rotation with the transfer member **34**. The planet carrier member **70**B is connected for common rotation with a second shaft or interconnecting member **82**.

The planetary gear set **72** includes a sun gear member **72**C, a ring gear member **72**A, and a planet carrier member **72**B that rotatably supports a set of planet gears **72**D (only one of which is shown). The planet gears **72**D are each configured to intermesh with both the sun gear member **72**C and the ring gear member **72**A. The sun gear member **72**C is connected for common rotation with the first shaft or interconnecting member **34**. The ring gear member **72**A is connected for common rotation with the transmission output member **22**. The planet carrier member **72**B is connected for common rotation with the second shaft or interconnecting member **82**. It should be appreciated that the ring gear member **70**C of the first planetary gear set **70** and the sun gear member **72**C of the second planetary gear set **72** may be formed from a single unitary member having inner and outer gear teeth or from separate gears connected together for rotation.

The torque-transmitting mechanisms or brakes **74**, **76** and clutch **78** allow for selective interconnection of the shafts or interconnecting members, members of the planetary gear sets and the housing. The torque-transmitting mechanisms are friction, dog or synchronizer type mechanisms or the like. For example, the first brake **74** is selectively engageable to connect the second shaft or interconnecting member **82** with the transmission housing **14** in order to restrict relative rotation of the member **82** and therefore the carrier member **70**B of the first planetary gear set **70** and the carrier member **72**B of the second planetary gear set **72**. The second brake **76** is selectively engageable to connect the first shaft or interconnecting member **80** with the transmission housing **14** in order to restrict relative rotation of the member **80** and therefore the sun gear member **70**A. In FIG. **7**A, the clutch **78** is selectively engageable to connect the ring gear member **72**A and the transmission output shaft **22** with the transfer shaft **34** and the ring gear member **70**C and sun gear member **72**C. Likewise, FIGS. **7**B-**3**F illustrate stick diagrams of the corresponding gearbox arrangements **26**H-**26**L which alter the location of the clutch **78**, as described above.

Turning now to FIGS. **8**A-F, another set of configurations of the gearbox **26** are shown in lever diagram format. The gearboxes illustrated in FIGS. **8**A-F include specific types of transmissions known as Simpson planetary gear sets, as will be described below. For example, the gearbox **26**M includes a first planetary gear set **90** and a second planetary gear set **92**. The first planetary gear set **90** has three nodes: a first node **90**A, a second node **90**B and a third node **90**C. The second planetary gear set **92** has three nodes: a first node **92**A, a second node **92**B and a third node **92**C.

The transfer member **34** is continuously coupled to the third node **90**C of the first planetary gear set **90**. The transmission output member **22** is coupled to the second node **92**B of the second planetary gear set **92**. The first node **90**A of the first planetary gear set **90** is coupled to the first node **92**A of the second planetary gear set **92**. The second node **90**B of the first planetary gear set **90** is coupled to the third node **92**C of the second planetary gear set **92**.

A first brake **94** selectively connects the second node **90**B of the first planetary gear set **90** and the third node **92**C of the second planetary gear set **92** with a stationary member or transmission housing **14**. A second brake **96** selectively connects the first node **90**A of the first planetary gear set **90** and the first node **92**A of the second planetary gear set with the stationary member or transmission housing **14**. A first clutch **98** selectively connects the first node **90**A of the first planetary gear set **90** and the first node **92**A of the second plan-

etary gear set **92** with the second node **90**B of the first planetary gear set **90** and the third node **92**C of the second planetary gear set **92**.

With reference to FIG. **8**B, an alternate gearbox arrangement **26**N is shown. The gearbox **26**N is similar to that shown in FIG. **8**A and therefore like components are indicated by like reference numbers. However, in FIG. **8**B, the first clutch **98** is relocated and selectively connects the first node **90**A of the first planetary gear set **90** and the first node **92**A of the second planetary gear set **92** with the second node **92**B of the second planetary gear set **92**.

With reference to FIG. **8**C, an alternate gearbox arrangement **26**O is shown. The gearbox **26**O is similar to that shown in FIG. **8**A and therefore like components are indicated by like reference numbers. However, in FIG. **8**C, the first clutch **98** is relocated and selectively connects the second node **90**B of the first planetary gear set **90** and the third node **92**C of the second planetary gear set **92** with the second node **92**B of the second planetary gear set **92**.

With reference to FIG. **8**D, an alternate gearbox arrangement **26**P is shown. The gearbox **26**P is similar to that shown in FIG. **8**A and therefore like components are indicated by like reference numbers. However, in FIG. **8**D, the first clutch **98** is relocated and selectively connects the second node **90**B of the first planetary gear set **90** and the third node **92**C of the second planetary gear set **92** with the third node **90**C of the first planetary gear set **90**.

With reference to FIG. **8**E, an alternate gearbox arrangement **26**Q is shown. The gearbox **26**Q is similar to that shown in FIG. **8**A and therefore like components are indicated by like reference numbers. However, in FIG. **8**E, the first clutch **98** is relocated and selectively connects the first node **90**A of the first planetary gear set **90** and the first node **92**A of the second planetary gear set **92** with the third node **90**C of the first planetary gear set **90**.

With reference to FIG. **8**F, an alternate gearbox arrangement **26**R is shown. The gearbox **26**R is similar to that shown in FIG. **8**A and therefore like components are indicated by like reference numbers. However, in FIG. **8**F, the first clutch **98** is relocated and selectively connects the third node **90**C of the first planetary gear set **90** with the second node **92**B of the second planetary gear set **92**.

Turning now to FIGS. **9**A-F, stick diagrams present schematic layouts of embodiments of the gearbox **26**M-R according to the present invention. In FIGS. **9**A-F the numbering from the lever diagram of FIGS. **8**A-F are carried over. The clutches and couplings are correspondingly presented whereas the nodes of the planetary gear sets now appear as components of planetary gear sets such as sun gears, ring gears, planet gears and planet gear carriers.

For example, the planetary gear set **90** includes a sun gear member **90**A, a ring gear member **90**C, and a planet carrier member **90**B that rotatably supports a set of planet gears **90**D (only one of which is shown). The planet gears **90**D are each configured to intermesh with both the sun gear member **90**A and the ring gear member **90**C. The sun gear member **90**A is connected for common rotation with a first shaft or interconnecting member **100**. The ring gear member **90**C is connected for common rotation with the transfer member **34**. The planet carrier member **90**B is connected for common rotation with a second shaft or interconnecting member **102**.

The planetary gear set **92** includes a sun gear member **92**A, a ring gear member **92**C, and a planet carrier member **92**B that rotatably supports a set of planet gears **92**D (only one of which is shown). The planet gears **92**D are each configured to intermesh with both the sun gear member **92**A and the ring gear member **92**C. The sun gear member **92**A is connected for common rotation with the first shaft or interconnecting member **100**. The ring gear member **92**C is connected for common rotation with the second shaft or interconnecting member **102**. The planet carrier member **92**B is connected for common rotation with the transmission output shaft **22**.

The torque-transmitting mechanisms or brakes **94**, **96** and clutch **98** allow for selective interconnection of the shafts or interconnecting members, members of the planetary gear sets and the housing. The torque-transmitting mechanisms are friction, dog or synchronizer type mechanisms or the like. For example, the first brake **94** is selectively engageable to connect the second shaft or interconnecting member **102** with the transmission housing **14** in order to restrict relative rotation of the member **102** and therefore the carrier member **90**B of the first planetary gear set **90** and the ring gear member **92**C of the second planetary gear set **92**. The second brake **96** is selectively engageable to connect the first shaft or interconnecting member **100** with the transmission housing **14** in order to restrict relative rotation of the member **100** and therefore the sun gear member **90**A and sun gear member **92**A. In FIG. **9**A, the clutch **98** is selectively engageable to connect the ring gear member **92**C and the carrier member **90**B with the sun gear member **90**A and the sun gear member **92**A. Likewise, FIGS. **9**B-**3**F illustrate stick diagrams of the corresponding gearbox arrangements **26**M-**26**R which alter the location of the clutch **98**, as described above.

It should be appreciated that where members of planetary gear sets or clutches and brakes are connected for common rotation they are directly connected for common rotation with no intervening torque transmitting devices or planetary gear set members. However, it should be appreciated that individual interconnecting members may be formed of one or more members or integrally formed with members of the planetary gear sets without departing from the scope of the present invention.

The description of the invention is merely exemplary in nature and variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

The following is claimed:

1. A powertrain for a motor vehicle comprising:

a transmission input member;

a transmission output member;

a continuously variable unit having a first pulley pair connected for common rotation with the transmission input member, a second pulley pair, and an endless member wrapped around the first pulley pair and the second pulley pair;

a first planetary gear set having a plurality of members;

a second planetary gear set having a plurality of members, wherein the second planetary gear set is connected for common rotation to the first planetary gear set, the continuously variable unit, and the transmission output member;

a clutch for selectively connecting for common rotation the first planetary gear set to the second planetary gear set;

a first brake for selectively connecting the first planetary gear set to a stationary member;

a second brake for selectively connecting the second planetary gear set to the stationary member;

a chain drive connected for common rotation with the transmission output member;

a transfer member connected for common rotation with the chain drive; and

a final drive planetary gear set connected for common rotation with the transfer member, and

wherein the powertrain includes only three axes of rotation from the transmission output member to the final drive planetary gear set.

2. The powertrain of claim **1** wherein the first planetary gear set includes a first member, a second member, and a third member and the second planetary gear set includes a first member, a second member, and a third member, wherein the first member of the first planetary gear set is connected for common rotation with the second member of the second planetary gear set, and the second member of the first planetary gear set is connected for common rotation with the third member of the second planetary gear set.

3. The powertrain of claim **2** wherein the first member of the second planetary gear set is connected for common rotation with the second pulley pair and the second member of the first planetary gear set and the third member of the second planetary gear set are connected for common rotation with the transmission output member.

4. The powertrain of claim **3** wherein the clutch selectively connects for common rotation the first member of the first planetary gear set and the second member of the second planetary gear set to the second member of the first planetary gear set and the third member of the second planetary gear set.

5. The powertrain of claim **4** wherein the first brake selectively connects the first member of the first planetary gear set and the second member of the second planetary gear set to the stationary member.

6. The powertrain of claim **5** wherein the second brake selectively connects the third member of the first planetary gear set to the stationary member.

7. The powertrain of claim **6** wherein the first member of the first planetary gear set and the second member of the second planetary gear set are integrally formed as a single rotating member.

8. The powertrain of claim **7** wherein the second member of the first planetary gear set and the third member of the second planetary gear set are integrally formed as a single rotating member.

9. The powertrain of claim **8** wherein the first member of the first planetary gear set is a ring gear, the second member of the first planetary gear set is a planet carrier member, the third member of the first planetary gear set is a sun gear, the first member of the second planetary gear set is a sun gear, the second member of the second planetary gear set is a ring gear, and the third member of the second planetary gear set is a planet carrier member.

10. The powertrain of claim **9** wherein the second member of the first planetary gear set and the third member of the second planetary gear set both support a plurality of stepped pinions and a plurality of pinions, wherein each of the plurality of stepped pinions have a first portion in mesh with the third member of the first planetary gear set and a second portion in mesh with the integrally formed first member of the first planetary gear set and the second member of the second planetary gear set and in mesh with the plurality of pinions, and wherein the plurality of pinions are in mesh with the first member of the second planetary gear set.

11. The powertrain of claim **1** wherein the final drive planetary gear set includes a first member, a second member, and a third member, wherein the first member is connected for common rotation with the transfer member, the second member is interconnected to road wheels of the motor vehicle, and the third member is connected to the stationary member.

12. The powertrain of claim **11** wherein the first member of the final drive planetary gear set is a sun gear, the second member of the final drive planetary gear set is a planet carrier member, and the third member of the final drive planetary gear set is a ring gear.

13. A powertrain for a motor vehicle comprising:

a transmission input member;

a transmission output member;

a continuously variable unit having a first pulley pair connected for common rotation with the transmission input member, a second pulley pair, and an endless member wrapped around the first pulley pair and the second pulley pair;

a planetary gear arrangement connected for common rotation with the second pulley pair and the transmission output member, wherein the planetary gear arrangement includes a first sun gear, a second sun gear, a planet carrier member, and a ring gear, wherein the planet carrier member supports a plurality of stepped pinions and plurality of non-stepped pinions, wherein the stepped pinions include a first portion in mesh with the first sun gear and a second portion in mesh with both the ring gear and the plurality of non-stepped pinions, and wherein the plurality of non-stepped pinions are each in mesh with the second sun gear;

a plurality of torque transmitting mechanisms for selecting multiple modes of gear ratio ranges between the continuously variable unit and the transmission output member;

a chain drive connected for common rotation with the transmission output member;

a transfer member connected for common rotation with the chain drive; and

a final drive planetary gear set connected for common rotation with the transfer member, and

wherein the powertrain includes only three axes of rotation from the transmission output member to the final drive planetary gear set.

14. The powertrain of claim **13** wherein the second sun gear is connected for common rotation with the second pulley pair of the continuously variable unit.

15. The powertrain of claim **13** wherein the planet carrier member is connected for common rotation with the transmission output member.

16. The powertrain of claim **13** wherein the plurality of torque transmitting mechanisms include a clutch that selectively connects for common rotation the planet carrier member to the ring gear.

17. The powertrain of claim **13** wherein the plurality of torque transmitting mechanisms include a first brake that selectively connects for common rotation the ring gear to a stationary member.

18. The powertrain of claim **13** wherein the plurality of torque transmitting mechanisms include a second brake that selectively connects for common rotation the first sun gear to a stationary member.

19. The powertrain of claim **13** wherein the final drive planetary gear set includes a first member, a second member, and a third member, wherein the first member is connected for common rotation with the transfer member, the second member is interconnected to road wheels of the motor vehicle, and the third member is connected to the stationary member.

20. The powertrain of claim **19** wherein the first member of the final drive planetary gear set is a sun gear, the second member of the final drive planetary gear set is a planet carrier member, and the third member of the final drive planetary gear set is a ring gear.

* * * * *